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IN THIS ISSUE

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Editor's Notes

Welcome to the second issue of the Silliman Journal for 2024! This edition highlights five full articles spanning a variety of disciplines.

The issue opens with "A Site Investigation of Pollution Along the Bantayan-Piapi Coastline, Dumaguete City, Philippines." In this article, Moses L. Alcala, Paulina S. Aspilla, Abner A. Bucol, and Socorro Z. Parco present findings from physico-chemical and bacteriological analyses of water samples from Mojon Creek and sewer outfalls along the Bantayan-Piapi coastline, uncovering severe pollution characterized by extremely high bacterial concentrations, elevated ammonia levels, and low dissolved oxygen. Their findings, which align with recent studies by the Silliman University Angelo King Center for Research and Environmental Management on microplastics in fish, offer critical insights and recommendations to address the area's significant environmental degradation.

The second article, "A Geochemical Investigation and Review of Hydrogeology of The Dumaguete Aquifer" by Duane G. Guevarra and Moses L. Alcala, examines the contamination risks faced by the Dumaguete aquifer, attributed to its unconfined nature, rapid urbanization, and the absence of municipal sewage treatment and landfill facilities. A hydrogeological review and geochemical investigation of groundwater samples from six barangays revealed elevated levels of pH, TDS, EC, salinity, sulfate, and coliform, with several sites exceeding regulatory standards for nitrate, phosphate, and dissolved oxygen. Highlighting significant environmental challenges, the study emphasizes the urgent need for groundwater monitoring and modeling to ensure the aquifer's long-term sustainability.

The third article, "Resilience and Coping Strategies of Junior High School Students in Dumaguete City" by Ma. Hezel B. Eumague and Jaruvic C. Rafols, investigates the relationship between resilience and coping strategies among 154 Junior High School students at Holy Cross High School Dumaguete. Findings reveal that students demonstrate high resilience, characterized by adaptability and goal-driven determination, and predominantly employ approach-oriented coping strategies to address challenges effectively, underscoring a significant link between resilience and their chosen coping mechanisms.

The fourth article, "Examining a Youth-led Participatory Video Process in Disaster Risk Reduction Management in a Philippine Rurban Community" by Trina Leah T. Mendoza and Benjamina Paula G. Flor, examines a youth-led participatory video (PV) process in disaster risk reduction management (DRRM) within a flood-prone community in Bay,

Laguna, Philippines, focusing on how youth conceptualize DRRM and PV. Through a PV training workshop, interviews, focus groups, and observations, participants emphasized disaster preparedness through information dissemination and capacity building, ultimately producing an advocacy video on typhoon preparedness. The study concludes that the PV process serves as both a learning platform and a community organizing strategy, empowering youth to co-create knowledge, develop critical awareness, and actively participate in DRRM initiatives as partners in development.

Finally, the fifth article, "Knowledge, Attitude, and Practices of Infection Prevention and Control among Healthcare Workers" by Estela Q. Catacutan, Novem Catherine E. Joseph, and Dave E. Marcial, evaluates infection prevention and control (IPC) practices among healthcare workers at Bais and Bindoy District Hospitals, focusing on their knowledge, attitudes, and practices and their relationship with demographic factors. Employing a non-experimental descriptive-correlational design, the research revealed that respondents generally had adequate IPC knowledge, reducing susceptibility to hospital-acquired infections. However, the study emphasizes the need for regular training programs and strict adherence to updated protocols to address gaps in knowledge and practices among healthcare workers.

The cover photo, titled "Distant Dreams," is by campus journalist Nathaniel E. Carampatana. Describing his work, he writes, "In the glow of a golden sky, shadows of boats drift across a tranquil sea, capturing the quiet poetry of life's endless voyage toward dreams and aspirations."

Warlito S. Caturay Jr. , PhD

A Site Investigation of Pollution Along the Bantayan-Piapi Coastline, Dumaguete City, Philippines

Moses L. Alcala[1,2], Paulina S. Aspilla[3], Abner A. Bucol[3,4], & Socorro Z. Parco[5]

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Abstract

Physico-chemical and bacteriological analyses were conducted on samples from the mouth of Mojon Creek at the north end of Silliman Beach, and sewer outfalls along the Bantayan-Piapi coastline. At each of the seven sampling stations, two samples were collected: one from the river mouth or outfall and a second from seawater located at least 20 m offshore. A supplementary underwater fish density and biomass survey was conducted in the shallow seagrass areas.

Extremely high levels of bacteria were detected in the samples, with concentrations of *E. coli* and enterococci ranging from one to five orders of magnitude exceeding the referenced standards and criteria. The concentrations of ammonia in all samples exceeded the referenced standards and criteria, thereby contributing to a toxic environment for aquatic organisms. Outfall effluent samples had non-detect to low dissolved oxygen (DO) levels, which were matched by high biochemical oxygen demand (BOD). A few outfall samples exceeded standards for oil and grease, total suspended solids (TSS), and phosphates. Based on a transect survey in the seagrass beds, the fish biomass and population density were notably low. The results of this study indicate significant pollution in the study area. This is supported by other recent data obtained by the Silliman University Angelo King Center for Research & Environmental Management (SUAKCREM). A concurrent, collaborative study on microplastics in fish gut confirmed the results of earlier studies by SUAKCREM on the occurrence of microplastics

in local fish catch.

Keywords: Dumaguete pollution, Silliman beach pollution, Piapi beach pollution, Coastal pollution, Fish biomass, Microplastics in fish gut, Bacterial pollution at beaches, Mojon Creek pollution

Executive Summary

This study was conducted to determine the physico-chemical and bacteriological characteristics of water from a river mouth and sewer discharges, and the nature of pollution along the coastal areas of barangays Bantayan and Piapi, Dumaguete City. Two sampling events were completed (September 8, 2022, and June 27, 2023). The following physico-chemical parameters were measured or analyzed for flow rate, temperature, pH, conductivity, salinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), oil and grease, total dissolved solids (TDS), total suspended solids (TSS), chloride, phosphate, ammonia, nitrite, and nitrate+nitrite. Enterococci and *E. coli* were quantified for bacteriological analysis. Seven sampling stations were established: one at the mouth of Mojon Creek and six at selected sewer outfalls (concrete pipes) along the coastline's seawall. At each sampling station, a second sample was collected offshore. The same parameters listed above (except for conductivity, oil and grease, TDS, and chloride) were obtained for the seawater samples at sampling points located at least 20 m directly offshore from each outfall sampling point.

The physico-chemical results indicated that high levels of ammonia and BOD, and low to non-detect levels of DO were associated with high bacteria levels at the Mojon Creek and outfall stations. At least four outfalls had ammonia levels (up to 15.017 mg NH_3-N/L) significantly exceeding the DENR's General Effluent Standard or GES (3 mg NH_3-N/L). This further indicated high levels of contamination in the effluent.

Ammonia levels in the offshore samples were as high as 0.39 mg NH3-N/L, which exceeded the DENR's Water Quality Guideline (WQG) of 0.06 mg NH_3-N/L. Two outfall samples indicated elevated oil and grease concentrations (8.6 and 8.8 mg/L), which exceeded the DENR's GES of 5 mg/L. Such elevated ammonia oil and grease levels contribute to a toxic environment for marine organisms.

The bacteriological results indicated that *E. coli* and enterococci levels exceeded their threshold limits. *E. coli* concentrations in the study area were as high as 47.2 million colony-forming units per 100 ml (CFU/100 ml) in effluent water at the outfalls and 25,500 CFU/100 ml in offshore seawater.

These were orders of magnitude higher than the DENR's General Effluent Standard or GES (200 CFU/100 ml) and Water Quality Guideline or WQG (100 CFU/100 ml). Such DENR standards and guidelines are for total coliform. Notably, the actual lab results (see Appendices A and B) for the samples reported both *E. coli* and total coliform, which were much higher than those values (i.e., for *E. coli* only) summarized in Tables 1 and 2.

Enterococci concentrations in the study area were as high as 51.6 million CFU/100 ml in effluent water at the outfalls and 28,900 CFU/100 ml in offshore seawater. These were also orders of magnitude higher than the referenced standards and criteria. Since the DENR does not specify any standards for enterococci, the sampling results were compared to existing USEPA recommended exposure limits (Recreational Water Quality Criteria, 35 CFU/100 ml), the New Jersey Surface Water Quality Standards or SWQS (30 CFU/100 ml), and the New Jersey Sanitary Code Water Quality Standards (104 CFU/100 ml, specifically for recreational beaches).

A supplementary biological investigation was conducted in the study area. Three survey transects (each one measuring 50 m x 10 m) were established offshore of Silliman and Piapi beaches. A rapid underwater survey (with photo-video documentation) was conducted to determine population density and biomass. The results were notably low. The shallow substrate's benthic composition was mainly dominated by mud and sand, with patches of seagrass and a few coral heads. A collaborative fish-gut microplastics study led by A. Bucol of SUAKCREM and biology students of the Negros Oriental State University (NORSU) was conducted in 2022 in concert with this physico-chemical study. The results indicated the occurrence of microplastics in the guts of fish collected in the study area, thereby confirming the results of previous studies conducted by SUAKCREM (A. Bucol, personal communication, February 2023).

The results of this study and other recent data provided by SUAKCREM reflect the effects of pollution in the past several decades in this coastal area. This study provides helpful information for the LGU and the country to comply with the 2030 UN Sustainable Development Summit 2015 goals. Recommendations for further studies and government action are therefore presented in the conclusion.

Introduction

This study was funded by the Silliman University Alumni Council of North America (SUACONA) and implemented by SUAKCREM to conduct a site investigation to characterize the discharges from sewer outfalls and

determine the presence and nature of pollution along the coastline and beaches of barangays Bantayan and Piapi. The coastal study area runs from Mojon Creek (along the south side of the Dumaguete airport runway), southwards up to the corner of the coastal road, Flores Avenue, and the east-west trending E.J. Blanco Drive. The study area had a total length of about 1,300 meters and a width ranging from 20 to 90 m from the seawall or shoreline, and it was addressed by seven sampling stations (see Figures 1A and 1B).

Figure 1A
Location of Study Area

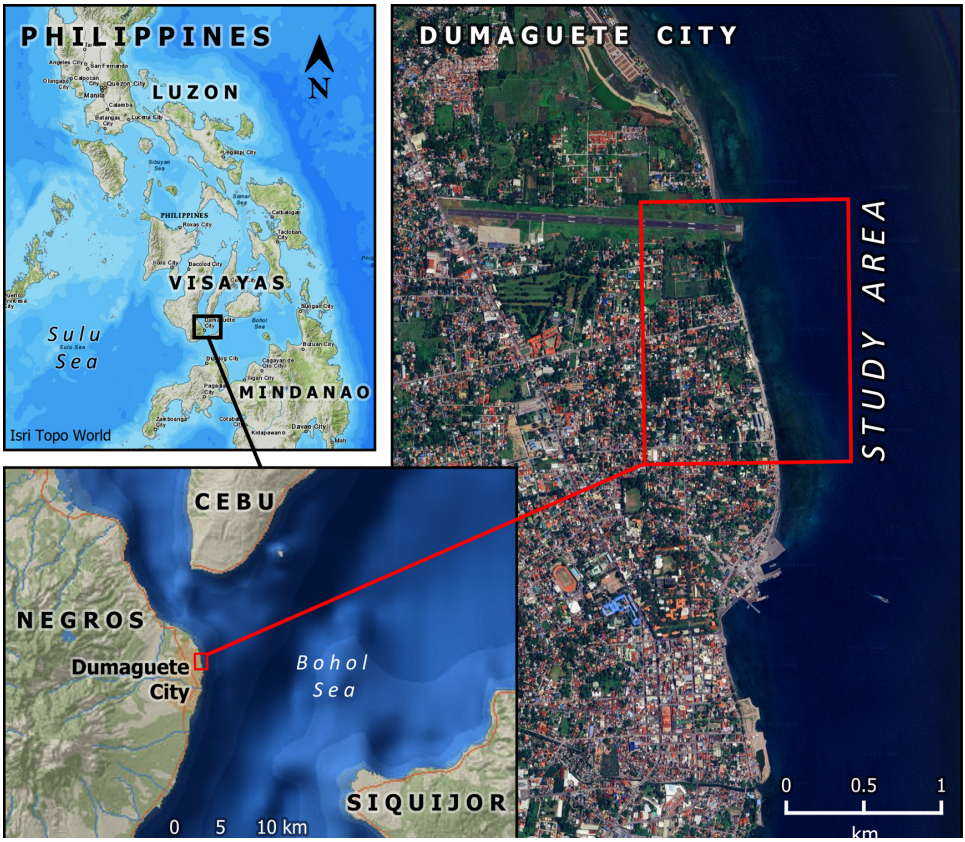

Figure 1B.
Map of the Study Area Showing the Locations of Sampling Stations (red triangles= outfalls and Mojon Creek; white triangles= offshore samples).

Silliman Beach in Bantayan is one of the few remaining free public beaches in Dumaguete City and possibly the most accessible and frequented

by the public all year round. The most crowded days were noted to be those with pre-scheduled all-day power outages in the city (Figure 1B). The length of the beach is approximately 340 meters. Several decades ago, it had been longer, extending an additional 165 meters southward, but such a portion is no longer part of the beach since a seawall and a roadway (with outdoor cafes alongside) have been constructed in that area. Due to natural scouring and erosion of beach sands since the 1970s (Alcala, 2002), the width of Silliman Beach is now only about 20 to 35 meters during non-spring tide high tide. Furthermore, polluted waters from Mojon Creek have been noted to discharge into the beach waters in the past few decades. Pollution (sewage odor, bluish or dark color, frequently silty, foamy discharge, garbage debris) has been noted along the downstream stretch and at the river mouth (Station 1) at the north end, and a major (one-meter diameter concrete pipe) sewer outfall (Station 2) at the south end of the beach.

The tributaries and headwaters of Mojon Creek have not been accurately mapped, but the headwaters are estimated to be within the City's western municipal limit, somewhere between the headwaters of Amlan River and the upper part of the mainstem of Banica River. The creek's tributaries and mainstem run through a highly urbanized area characterized by numerous residential communities and commercial properties (e.g., stores, restaurants, commercial and professional office buildings), a few agricultural parcels (e.g., Silliman Farm), a university campus, a golf course, and several light-industrial facilities (e.g., vehicle repair, warehouses, gas stations, auto and motorcycle dealers).

The one-meter diameter sewer pipe at Station 2 was noted to discharge a combined wastewater-stormwater effluent from numerous residences in the adjacent coastal village and residential communities west of Silliman Beach. Similarly, all the other outfalls (Stations 3 through 7) had combined wastewater and stormwater discharge effluent. The wastewater is presumed to consist mostly of graywater since underground septic systems are required for blackwater in the city.

South of Silliman Beach is what remains of Escano Beach in Barangay Piapi. It is about 800 meters long, from East Rovira Road to E.J. Blanco Drive. The beach was already originally narrow but is now mostly covered by a coastal road (Flores Avenue) and seawall. The original beach face, berm, and backshore no longer exist. Some beachgoers still do recreational activities in front of the seawall (e.g., beachcombing during low tide, swimming, and canoeing).

There has been extensive commercial development along this coastal area of Barangay Piapi since the 1970s-mostly hotels, condominiums, and

restaurants, beyond which (to the west) are numerous residential properties and commercial stores (further west, along Hibbard Avenue). For this study, five sampling stations at existing outfall pipes (with combined wastewater-stormwater effluent) were established along Escano Beach. The outfalls at Stations 2 through 7 consist of one-meter diameter concrete pipes along the seawall of the coastline. (See Fig.2 for photos of typical outfall pipes.)

Anecdotal information from some people who bathe or swim at Silliman Beach includes reports of skin irritation and rashes, eye irritation, and chronic skin disease. During sampling and several site visits in 2022 and 2023, observation of the sewer outfall areas as well as the mouth of the Mojon Creek consistently indicated the presence of contamination based on sewer odor, periodic foaming, dark or bluish-white coloration, and plastic and other garbage debris.

The study area is within the larger fishing grounds of the coastal community, which includes a delineated Marine Protected Area (MPA) in the deeper area. Thus, in addition to the physico-chemical and bacteriological study, a supplemental fish biomass and population density survey was conducted by A. Bucol of this study's research team. He also coordinated a collaborative microplastics investigation in 2022 with cooperation from biology students of NORSU.

This study aimed to document the presence and nature of pollution, with results that provided the basis for recommendations for further studies and remedial action.

Methods

Sampling Stations

The sampling stations comprised one river mouth (Mojon Creek, Station 1) and six sewer outfalls characterized by one-meter diameter concrete pipes that discharge sewage effluent and stormwater (Stations 2 through 7). These sampling stations are shown on the map in Figure 1b. Photos of the river mouth and three outfalls are shown in Figures 2A through 2F. At each station, two water samples were collected: one directly from the outfall pipe (freshwater effluent samples A1 through A7 from Stations 1 through 7) and the other from offshore seawater at a sampling point located roughly 20 m from the outfall (samples B2 through B6 from Stations 2 through 6). However, offshore samples B1 and B7 (at Stations 1 and 7) were located much farther seaward (approximately 80 to 90 m) due to the emergence of sand bars during sampling at low tide. The sampling depth

for the "B" series samples was approximately 50 to 60 cm, midway between the surface and bottom of the water column.

Figure 2A. River mouth of Mojon Creek, Station 1
Note: heavily silted with plastic debris. 5-28-2023

Figure 2B. Sewer outfall south of Station 2
12-15-2023

Figure 2C. Sewer outfall, Station 3.
Note: foamy, bluish and whitish effluent. 8-26-2022

Figure 2D. South end of Silliman Beach. View of Station 2 and offshore part of study area. 12-15-2023

Figure 2E. Station 6. Note: seawall, coastal road, and ongoing construction of condominium. 9-8-2022

Figure 2F. Silliman Beach. Highly crowded on a power-outage day. 2-12-2023

For data reliability, two rounds of sampling were performed at the stations- the first on September 8, 2022, and the second on June 27, 2023. Such time of year coincided with the rainy season as well as the Habagat (southwest monsoon), which is characterized by lower energy of waves compared to the stronger Amihan (northeast monsoon) waves in this part of Negros Island. The two sampling events were scheduled during low tide and within 24 to 48 hours of a significant rainstorm (Bacteria levels are

highest during and after rainstorms due to high runoff rates.) (Barboza, 2014). During the second sampling round, physico-chemical parameters for Station 2 could not be obtained since the outfall remained inaccessible throughout the day of sampling. Additionally, TDS analysis of offshore samples was not conducted since pollutant concentrations would be masked by natural salt in seawater.

Physico-chemical Parameters

At each sampling station, the following physico-chemical parameters were measured: 1) water temperature using a digital temperature meter (°C); 2) pH using a portable pH meter; 3) dissolved oxygen (DO) using the Winkler titration method; 4) salinity using a refractometer; and 5) conductivity using a conductivity meter (for outfall samples). Samples for DO were treated with $MnSO_4$ and alkaline KI in the field and further processed in the lab on the same day. A certain volume was diluted to a specified volume for samples that appeared highly contaminated. As with undiluted samples, DO levels were measured before and after a 5-day incubation period, considering the dilution factor for quantification of BOD. All bottles were covered in black plastic bags while not processed or during incubation.

Additionally, at each station, aliquots for water samples (4 liters each from outfall and seawater) were collected and immediately transported to the Silliman University Chemistry Laboratory for further lab processing and analysis of total suspended solids (TSS via gravimetric method), total dissolved solids (TDS, via a gravimetric method, for outfall samples), oil and grease (via hexane extraction and gravimetry, for outfall samples), chloride (via Mohr method, for outfall samples), phosphate (via colorimetry, USEPA Method 365.3), ammonia, nitrate+nitrite (via cadmium reduction and colorimetry, USEPA Method 353.3), and bacteria. Quantification of ammonia, NH_{-3}, was achieved using the method known as "formation of a substituted indophenol with sodium salicylate as phenolic reagent," a specific analysis for ammonia-nitrogen (Verdouw et al., 1978) with results reported in milligrams of ammonia-nitrogen per liter (mg NH_{-3} -N/L).

Water Discharge Rates

At the Mojon Creek and outfalls with larger volume discharges (i.e., Stations 6 and 7), flow rates were measured using a flow meter (General Oceanics, Model 2030R Mechanical Flowmeter). Flow rates were determined at the outfalls with low discharge using the bucket and

stopwatch method (volume in liters measured after 10 seconds elapsed). These methods were based on the wastewater flow measurement procedures of the USEPA (USEPA, 2020).

Bacteriological

Water sample aliquots were collected for coliform (*E. coli*) and enterococci quantification using sterile tubes prepared at the lab before the sampling events. Dilution plating and inoculation were completed on culture plates (Compact DryTM). Following the manufacturer's procedures, these were incubated for 24 hours at 35ºC at the SU Biology Laboratory. Quantification involved the use of the standard plate count method. *E. coli,* total coliform, and enterococci were originally reported as the number of colony-forming units per milliliter of sample volume (CFU/ml). The unit was later converted and tabulated as CFU/100 ml to compare with the referenced regulatory standards.

Fish Census and Biomass

The supplementary fish census and biomass study were conducted in 2022 via a rapid underwater survey, setting up three transects (50 m x 10 m) offshore between Stations 2 and 5. Using photo-video documentation, an observer (A. Bucol) identified and counted all observed fish while skin diving. The areas covered by the transects excluded the delineated Bantayan Marine Protected Area located adjacent to the study area. The fishes were identified based on taxonomic reference books (e.g., Erdmann & Allen, 2012).

The sizes and counts of each species of fish were recorded to compute fish biomass. Such data was used to estimate weight (W) in grams using the formula W=a*Lb; where a and b are constants derived from fishbase.org and L refers to the estimated total length. The fish population density of an area is expressed as individuals/500m2.

Results

Figures 3 through 12 summarize the results of the first and second rounds of sampling in plot graph format. Tables 1 to 2 are detailed summary tabulations of results for the two rounds of sampling, with referenced standards and criteria added. (Lab data sheets containing more analytical details such as standard error and mean values for each set of three trial

measurements are available upon request.)

Physico-chemical Parameters

The offshore samples' water temperatures (see Fig. 3) were slightly higher (32-32.5°C at Station 2) than those of the effluent samples at the outfalls. The average value of offshore water was 30.8°C in both September 2022 and June 2023 sampling events, slightly higher than the average of 30.1°C at the outfalls.

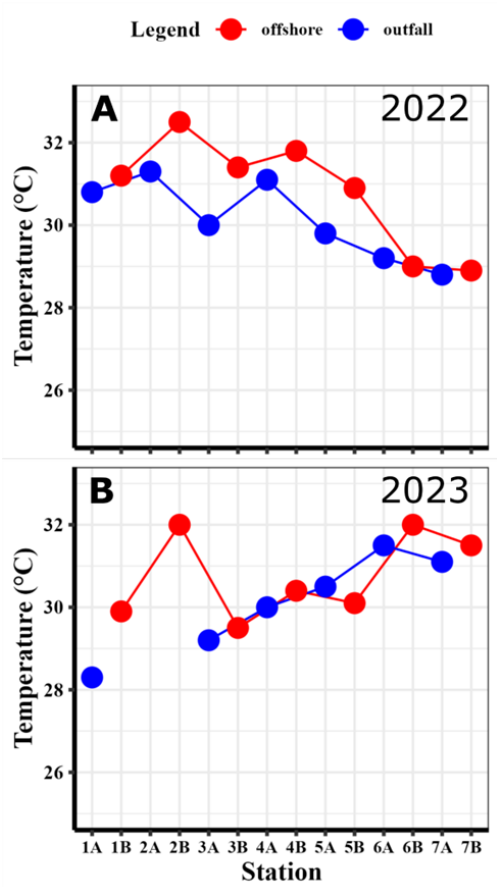

Figure 3. Water temperature readings across the sampling stations.
(blue= outfall, red= offshore sample stations).

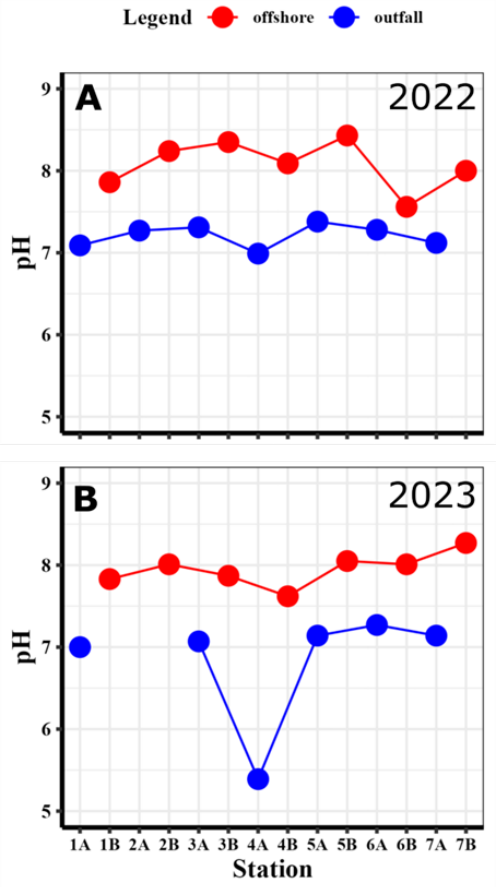

Figure 4. pH readings across the sampling stations.

The pH values (Fig. 4) of the offshore samples were typical of seawater (alkaline, with an average of 8.08 in 2022 and 7.95 in 2023, and a range of 7.56 – 8.43) while pH was lower at the outfalls (levels of 5.4 –7.4). Station 4 had the lowest pH (at 5.39), indicating acidic discharge, which

in turn suggested high levels of contamination. This is supported by non-detect DO, high BOD (6.35 mg/L), high TSS (131 mg/L), high ammonia (12.6 mg NH_4-N/L), and the highest levels of bacteria (47.2 million *E. coli* colony-forming units or CFU per 100 ml, and 51.6 million enterococci CFU/100 ml).

DO concentrations (Fig. 5) were mostly lower in the outfall samples, particularly at Stations 3, 4, and 5 (≤ 0.63 mg/L), compared to that of the seawater samples (4.9 –10.16 mg/L in 2022 and 5.4 – 8.1 mg/L in 2023). Station 1 (Mojon Creek) and the outfall samples from Stations 6 and 7 had higher DO levels compared to the rest of the outfalls. This is attributable to higher flow rates and turbulence of the stream. The low DO levels at the outfall Stations 3, 4, and 5 correlate to higher levels of contamination, as indicated by the highest levels of bacteria. It should be noted that some DO results reported as "ND" indicated non-detect values, which meant that DO was not detected above the detection limit (Winkler titration method, with a detection limit of 0.06 mg O_2 per liter).

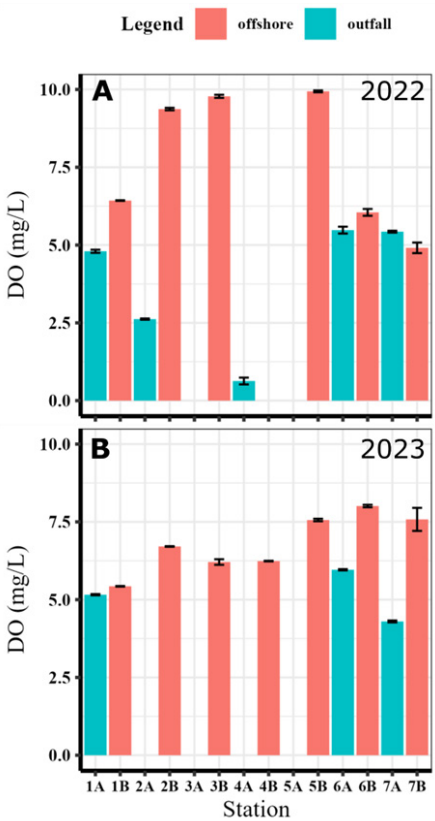

Figure 5. Dissolved oxygen readings across the sampling stations. (teal= outfall, red=offshore).

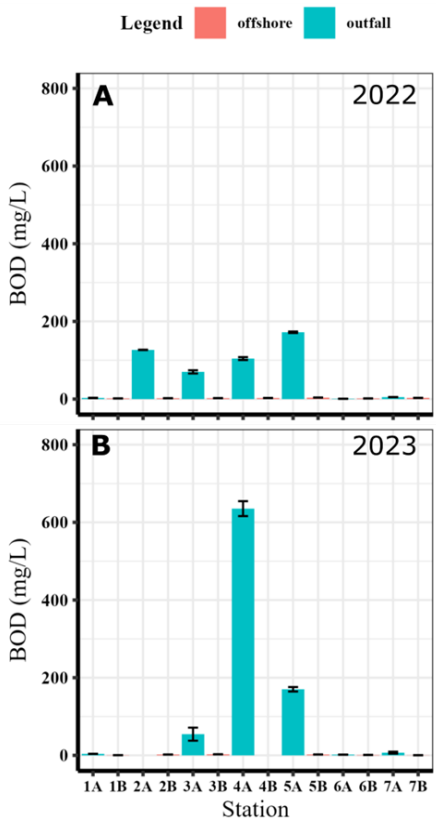

Figure 6. BOD readings across the sampling stations.

Biochemical oxygen demand (BOD) was generally higher in the outfall samples, with the highest levels detected in 2023 at Station 4 (BOD at 635.3 mg/L) and Station 5 (BOD at 170.2 mg/L). These elevated BOD levels were consistent with the low DO trends, thus indicating higher levels of contamination. The offshore samples generally had BOD below 5.0 mg/L (Fig. 6), suggesting dispersion of contamination from the outfalls.

Except for two stations (6 and 7), salinity readings (Fig. 7) at the outfalls were indicative of freshwater effluent (salinity of 0 parts per thousand, ppt). In contrast, the relatively elevated (19–20 ppt) salinity values at outfall Stations 6 and 7 (noted in both sampling rounds) may be attributable to significant saltwater intrusion into the shallow coastal groundwater and/or into the sewer lines (e.g., during the pre-sampling high tide events) at these two locations. This high salinity trend is supported by the elevated chloride (at >9,000 mg Cl/L), conductivity (≥15.93 milliSiemens per cm, mS/cm), and TDS (>16,000 mg/L) at Stations 6 and 7.

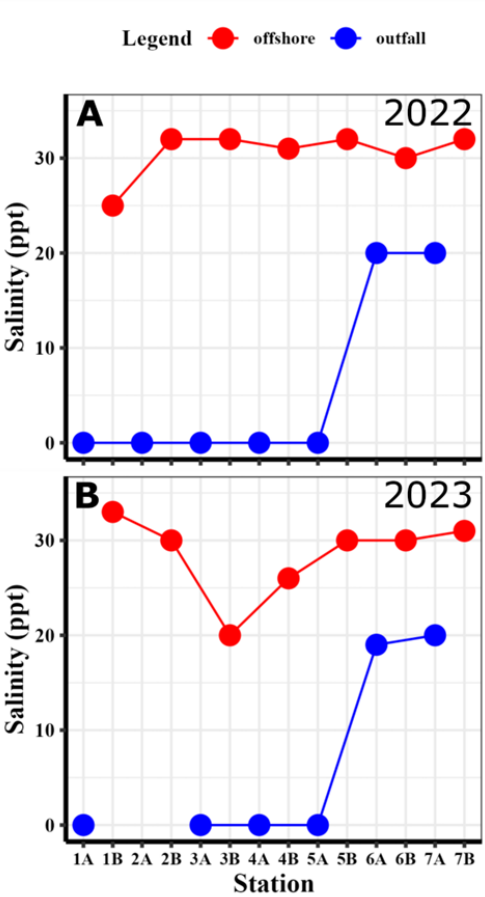

Figure 7. Salinity across the sampling stations.

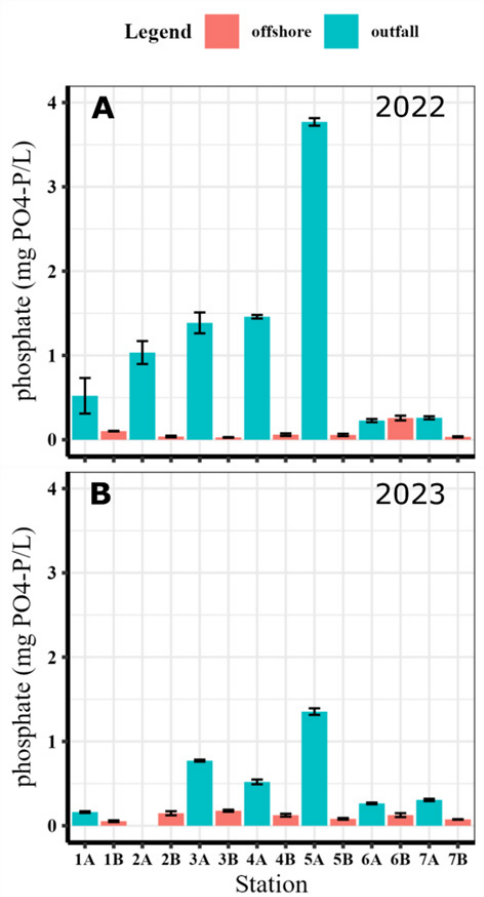

Figure 8. Phosphate concentrations across the sampling stations in 2022 (A) and 2023 (B).

Salinity readings from offshore samples were close to the typical value for seawater, 35 parts per thousand (ppt). The lower salinity values at the mouth of Mojon Creek (25 ppt at Station 1 during the 2022 sampling round) can be attributed to freshwater mixing. Stations 3 and 4 (with 20 and 26 ppt salinity values in the 2023 sampling round) also indicated significant freshwater (from the outfalls) mixing at the offshore sampling points.

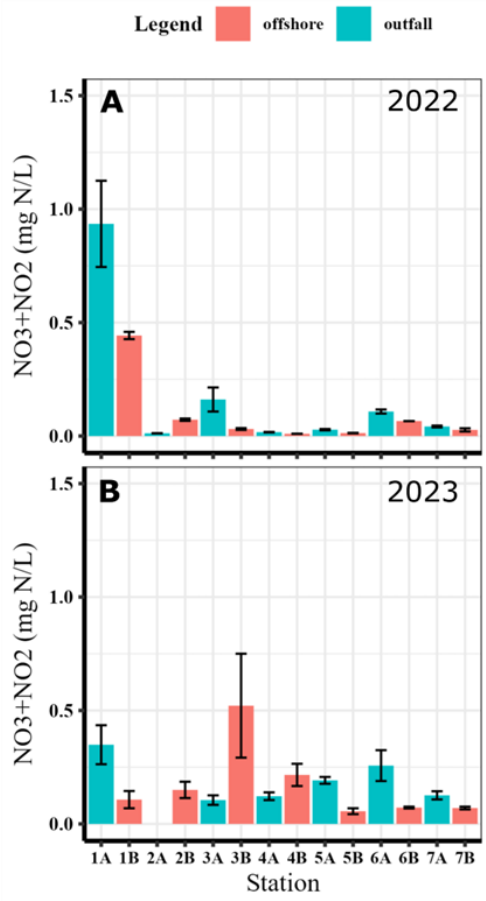

Figure 9. Total nitrogen (Nitrate+Nitrite, A-2022, B-2023) concentrations across the sampling stations.

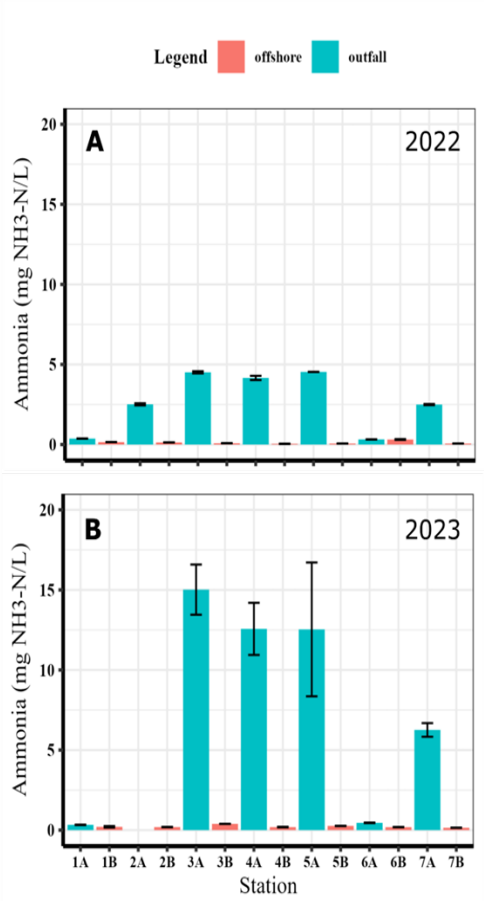

Figure 10. Ammonia (A-2022, B-2023) concentrations across the sampling stations.

The presence of phosphate (see Fig. 8) and total nitrogen (from combined nitrate and nitrite, NO_3+NO_2) (Fig. 9) in the samples suggested anthropogenic pollution due to discharge of domestic and commercial effluent, e.g., gray water or wastewater from washing and laundry activities, into the storm sewer system. (It is noted that there is no centralized municipal sewerage treatment system in the city.) During sample collection, outfall Stations 3 through 7 exhibited brownish to bluish-white and foamy discharges typical of wastewater containing sediment and detergents or

soaps. All sampling results showed significant phosphate levels (ranging from 0.16 to 3.77 mg of P per liter) and total nitrate-nitrite concentrations (ranging from 0.11 to 0.94 mg of N per liter). Old and leaky septic tanks in the area may also be contributing to phosphate and nitrate-nitrite contamination of effluent. Kaczmarsky and Richardson (2011) reported the presence of elevated nitrogen and phosphorus levels in sediment and seawater samples south (from Piapi to the Dumaguete pier area) of this study area. Such contamination was correlated to coral disease infection.

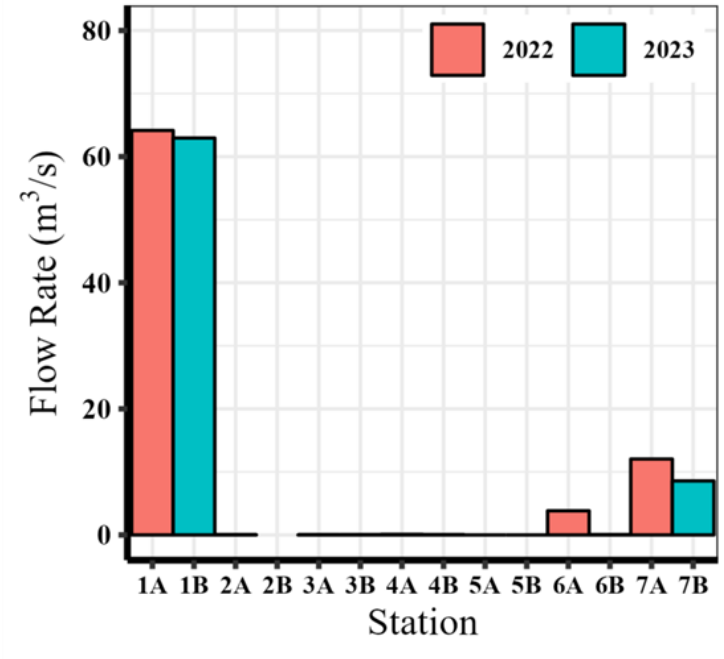

Figure 11. Water discharge rates at sewage outfalls and Mojon Creek mouth

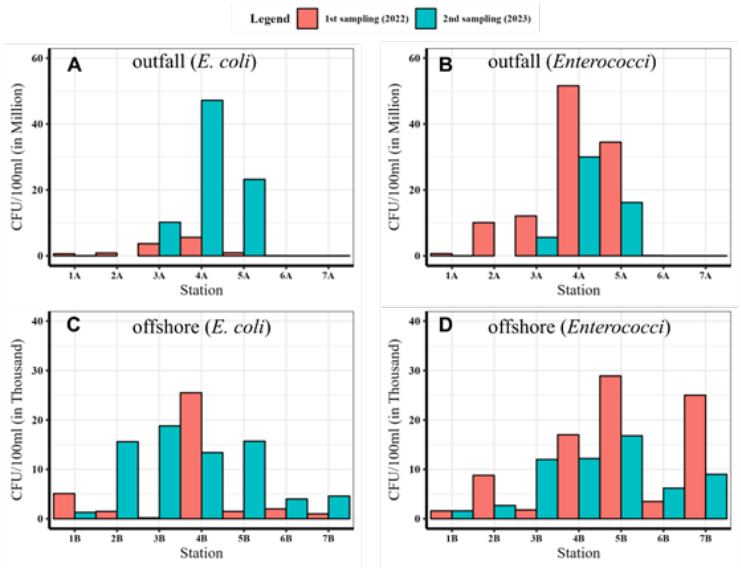

Figure 12. Bacterial colony forming units (CFU/100 ml) of *E. coli* and Enterococci from sewage outfalls (A and B) and offshore seawater samples (C and D). CFUs in outfalls in Millions/100ml and offshore sites in Thousands/100ml.

The discharges from the river mouth and outfall stations were also highly enriched in ammonia, with values (in 2022) ranging from 0.32 to 4.5 mg of ammonia-nitrogen per liter (mg NH_3-N/L). In 2023, a sharp increase was noted at outfall Stations 3, 4, and 5 (12.533 to 15.017 mg NH_3-N/L; see Fig. 10). Such difference may have been due to variability of activities responsible for ammonia discharge in this highly commercialized area, as well as the complex nature of nitrogen fixation, nitrification, and ammonia–ammonium reactions. Like phosphate contamination, such elevated ammonia levels can also be attributed to domestic and commercial wastewater discharges into the sewer system in this area.

Water discharge or flow rate (Fig. 11) was logically highest at the mouth of Mojon Creek, with a measured flow rate of 63 – 64 m^3/s. The subsequent highest flow rates (4 and 12 m^3/s) were noted at the two outfall Stations 6 and 7, respectively. Discharge at Station 6 was observed to be highly variable and occurring in pulses, as noted during the second sampling round. There appears to be an unusual correlation between high flow rates and relatively high salinity at outfall Stations 6 and 7. These conditions may be due to one or a combination of the following factors: leaky sewer pipes, high permeability of soil material, shallow water table, and saltwater intrusion (e.g., in groundwater or the sewer pipes during pre-sampling high tide). The higher flow rates at outfall Stations 6 and 7 also coincide with recent construction (including ongoing utility excavation) and the

numerous restaurants, hotels, and a large condominium complex in this section of Piapi. Since the two rounds of sampling were conducted within 24 to 48 hours after a rainstorm, discharge rates are much lower during the longer periods of dry weather or between rainstorms, as noted during several random site visits in 2022 and 2023.

Bacteriological Analysis

Bacteria levels were very high across the sampling stations (Fig. 12, A–D). Mean colony forming units per 100 ml (CFU/100 ml) of *E. coli* in samples from the outfalls ranged from 30,600 to 5,600,000 in the first sampling round and 4,600 to 47,200,000 in the second sampling round, with Station 4 consistently having the highest levels. In the seawater samples, *E. coli* concentrations were notably lower than those from the outfalls, ranging from 200 to 25,500 CFU/100 ml. Such lower concentrations of *E. coli* in seawater are attributable to dispersion from the point sources (outfalls) and the typical intolerance of *E. coli* to salinity.

The enteroccoci concentrations in the outfall samples ranged from 12,000 to 51,625,000 CFU/100 ml in the first sampling round and 2,500 to 30,000,000 CFU/100 ml in the second sampling round (with highest levels at Station 4). As in the case of *E. coli*, the enteroccoci concentrations in the seawater samples were also lower than in the outfall samples, ranging from 1,600 to 28,900 CFU /100 ml and 1,600 to 16,800 CFU/100 ml in 2022 and 2023, respectively. Since enterococci are known to be salinity-tolerant bacteria (Byappanahalli et al., 2012), their significant decrease in concentration from outfall to open seawater may be attributable to dispersion and other factors that deserve further study.

Table 1.
Tabulation of analytical results and reference limits
Sewer and surface water discharge along the Bantayan-Piapi coastline
First round of sampling, September 8, 2022

Sampling Station/ Regulatory limits	Lab ID	Temp, °C	pH	Conductivity, mS/cm	Salinity, ppT	DO, mg/L	BOD, mg/L	Oil & Grease, mg/L	TDS, mg/L	TSS, mg/L	Chloride, mg/L	PO_4, mg PO_4-P/L	NH_3, mg NH3-N/L	NO_2, mg NO_2-N/L	NO_3+NO_2, mg N/L	*E. Coli*, CFU/100 ml	*Enterococci*, CFU/100 ml
DENR, GES		–	*6.5-9.0*	–	–	*≥6*	*30*	*5*	–	*70*	–	*2*	*3*	–	*20 (NO_3)*	*200**	–
NJDOH, SCWQS		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*104*
NJDEP, SWQS		–	*Natural pH levels*	–	–	*≥5*	–	*Non-noticeable*	–	*Suitable for use*	–	***	*Acute 0.094/ chronic 0.024*	***	***	*100***	*30*
USEPA, RWQC		–	–	–	–	–	–	–	–	–	–	–	–	–	–	*126***	*35*
Sta 1 River mouth	A1	30.8	7.09	1.16	0	**4.80**	2.86	3.4	911	34	252.1	0.52	**0.372**	0.149	0.935	**650,000**	**700,000**
Sta 2 Outfall	A2	31.3	7.27	0.88	0	**2.62**	**126.60**	<2	651	6	92.6	1.03	**2.510**	0.002	0.012	**850,000**	**10,100,000**
Sta 3 Outfall	A3	30.0	7.31	0.89	0	**ND**	**70.01**	4.4	661	17	123.8	1.39	**4.509**	0.008	0.161	**3,700,000**	**12,100,000**
Sta 4 Outfall	A4	31.1	6.99	1.06	0	**0.63**	**104.29**	**8.8**	832	41	145.8	1.46	**4.159**	0.002	0.017	**5,600,000**	**51,625,000**
Sta 5 Outfall	A5	29.8	7.38	2.26	0	**ND**	**172.03**	**8.6**	1,532	47	496.9	**3.77**	**4.536**	0.013	0.028	**925,000**	**34,500,000**
Sta 6 Outfall	A6	29.2	7.28	15.93	20	**5.48**	0.87	<2	20,815	40	11,682.9	0.23	**0.320**	0.003	0.108	**59,500**	**100,000**
Sta 7 Outfall	A7	28.8	7.12	>19.99	20	**5.43**	4.92	2.2	16,966	**96**	10,793.6	0.26	**2.494**	<0.0006	0.042	**30,600**	**12,000**
	Average	*30.1*	*7.21*	*6.02*	*5.7*	***2.71***	***68.80***	***5.5***	*6,053*	*40*	*3,369.7*	*1.24*	***2.700***	*0.025*	*0.186*	***1,687,871***	***15,591,000***

DENR, WQG		26-30	*7-8.5*	–	–	*≥6*	–	*2*	–	*50*	–	*0.20*	*0.06*	–	*10 (NO_3)*	*100**	–
NJDOH, SCWQS		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*104*
NJDEP, SWQS		–	*Natural pH levels*	–	–	*≥5*	–	*Non-noticeable*	–	*Suitable for use*	–	***	*Acute 0.094/ chronic 0.024*	***	***	*100***	*30*
USEPA, RWQC		–	–	–	–	–	–	–	–	–	–	–	–	–	–	*126***	*35*
Sta 1 Offshore	B1	31.2	7.86	NA	25	6.43	1.68	NA	NA	**65**	NA	0.10	**0.151**	0.033	0.443	**5,100**	**1,600**
Sta 2 Offshore	B2	32.5	8.24	NA	32	9.37	2.13	NA	NA	**63**	NA	0.04	**0.134**	0.003	0.072	**1,500**	**8,800**
Sta 3 Offshore	B3	31.4	8.35	NA	32	9.78	2.27	NA	NA	28	NA	0.03	**0.083**	0.002	0.031	**200**	**1,800**
Sta 4 Offshore	B4	31.8	8.09	NA	31	10.16	2.64	NA	NA	35	NA	0.06	**0.046**	<0.0006	0.010	**25,500**	**17,000**
Sta 5 Offshore	B5	30.9	8.43	NA	32	9.94	3.71	NA	NA	34	NA	0.06	**0.063**	0.002	0.013	**1,500**	**28,900**
Sta 6 Offshore	B6	29.0	7.56	NA	30	6.05	1.59	NA	NA	**115**	NA	**0.26**	**0.315**	0.003	0.066	**2,000**	**3,500**
Sta 7 Offshore	B7	28.9	8.00	NA	32	**4.91**	3.08	NA	NA	**75**	NA	0.03	**0.064**	<0.0006	0.027	**1,000**	**25,000**
	Average	***30.8***	*8.08*		*30.6*	*8.09*	*2.44*			***59***		*0.08*	***0.122***	*0.006*	*0.095*	***5,257***	***12,371***

Notes:

Value in **bold** indicates exceedance of any referenced limit
– Indicates no applicable or referenced standard/guideline/criteria
ppT= parts per thousand
mS/cm= milliSiemens per centimeter
***** Total fecal coliform (includes E. Coli)
****** applies to freshwater surface water body
******* Except as due to natural conditions, nutrients shall not be allowed in concentrations that render the waters unsuitable for the existing or designated uses
NA= Not analyzed for
ND= Dissolved oxygen not detected by analytical method
< = Not detected at the given detection limit
DENR= Philippine Dept of Environment and Natural Resources
USEPA= U.S. Environmental Protection Agency
NJDOH/NJDEP= New Jersey Dept of Health/ New Jersey Dept of Environmental Protection
GES= General Effluent Standards, Class SB Coastal Waters (DENR, DAO 2016-08/DAO 2021-19, regulatory); applies to point sources of pollution
WQG= Water Quality Guidelines; for water quality management purposes, Class SB Coastal Waters (DENR, DAO 2016-08/DAO 2021-19, not intended for enforcement)
RWQC= Recreational Water Quality Criteria (USEPA, recommended criteria, geometric mean, updated 2012)
SCWQS= Sanitary Code Water Quality Standards (NJDOH, regulatory, for bathing beaches)
SWQS= Surface Water Quality Standards (NJDEP, regulatory); for saline coastal (SC) waters unless otherwise indicated

Table 2.
Tabulation of analytical results and reference limits
Sewer and surface water discharge along the Bantayan-Piapi coastline
Second round sampling, June 27, 2023

Sampling Station/ Regulatory limits	Lab ID	Temp, ˚C	pH	Conductivity, mS/cm	Salinity, ppT	DO, mg/L	BOD, mg/L	Oil & Grease, mg/L	TDS, mg/L	TSS, mg/L	Chloride, mg/L	PO_4, mg PO_4-P/L	NH_3, mg NH_3-N/L	NO_2, mg NO_2-N/L	NO_3+NO_2, mg N/L	*E. Coli*, CFU/100 ml	*Enterococci*, CFU/100 ml
DENR, GES		–	*6.5-9.0*	–	–	*≥6*	*30*	*5*	–	*70*	–	*2*	*3*	–	*20 (NO_3)*	*200**	–
NJDOH, SCWQS		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*104*
NJDEP, SWQS		–	*Natural pH levels*	–	–	*≥5*	–	*Non-noticeable*	–	*Suitable for use*	–	***	*Acute 0.094/ chronic 0.024*	***	***	*100***	*30*
USEPA, RWQC		–	–	–	–	–	–	–	–	–	–	–	–	–	–	*126***	*35*
Sta 1 River mouth	A1	28.3	7.00	0.4	0	**5.2**	3.8	NA	323	31	23.4	0.16	**0.329**	0.150	0.349	**42,600**	**22,800**
Sta 2 Outfall	A2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sta 3 Outfall	A3	29.2	7.07	0.7	0	**ND**	**54.6**	NA	423	12	78.3	0.77	**15.017**	0.023	0.105	**10,200,000**	**5,600,000**
Sta 4 Outfall	A4	30.0	**5.39**	1.1	0	**ND**	**635.3**	NA	885	**131**	163.8	0.52	**12.566**	0.042	0.122	**47,200,000**	**30,000,000**
Sta 5 Outfall	A5	30.5	7.14	1.0	0	**ND**	**170.2**	NA	443	60	75.3	1.35	**12.533**	0.028	0.192	**23,200,000**	**16,200,000**
Sta 6 Outfall	A6	31.5	7.27	>20	19	**6.0**	1.9	NA	17,933	15	9,887.1	0.27	**0.455**	0.041	0.257	**4,600**	**2,500**
Sta 7 Outfall	A7	31.1	7.14	19.9	20	**4.3**	6.9	NA	20,237	56	9,510.8	0.31	**6.256**	0.041	0.126	**41,500**	**14,000**
	Average	*30.1*	*6.84*	*7.2*	*6.5*	***2.6***	***145.4***		*6,707*	*51*	*3,289.8*	*0.56*	***7.859***	*0.054*	*0.192*	***13,448,117***	***8,639,883***

DENR, WQG		26-30	*7-8.5*	–	–	*≥6*	–	*2*	–	*50*	–	*0.20*	*0.06*	–	*10 (NO_3)*	*100**	–
NJDOH, SCWQS		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*104*
NJDEP, SWQS		–	*Natural pH levels*	–	–	*≥5*	–	*Non-noticeable*	–	*Suitable for use*	–	***	*Acute 0.094/ chronic 0.024*	***	***	*100***	*30*
USEPA, RWQC		–	–	–	–	–	–	–	–	–	–	–	–	–	–	*126***	*35*
Sta 1 Offshore	B1	29.9	7.83	NA	33	**5.4**	0.6	NA	NA	34	NA	0.05	**0.205**	0.002	0.107	**1,300**	**1,600**
Sta 2 Offshore	B2	32.0	8.01	NA	30	6.7	2.2	NA	NA	38	NA	0.15	**0.190**	0.014	0.150	**15,600**	**2,700**
Sta 3 Offshore	B3	29.5	7.87	NA	20	6.2	2.7	NA	NA	21	NA	0.18	**0.390**	0.021	0.521	**18,800**	**12,000**
Sta 4 Offshore	B4	30.4	7.62	NA	26	6.2	No data	NA	NA	21	NA	0.13	**0.189**	0.011	0.216	**13,400**	**12,200**
Sta 5 Offshore	B5	30.1	8.05	NA	30	7.6	2.2	NA	NA	27	NA	0.08	**0.263**	0.005	0.056	**15,700**	**16,800**
Sta 6 Offshore	B6	32.0	8.01	NA	30	8.0	1.0	NA	NA	33	NA	0.13	**0.186**	0.005	0.072	**4,000**	**6,200**
Sta 7 Offshore	B7	31.5	8.27	NA	31	7.6	0.4	NA	NA	**75**	NA	0.08	**0.147**	0.003	0.070	**4,600**	**9,000**
	Average	***30.8***	*7.95*		*29*	*6.8*	*1.5*			*36*		*0.11*	***0.224***	*0.009*	*0.170*	***10,486***	***8,643***

Notes:

Value in **bold** indicates exceedance of any referenced limit
– Indicates no applicable or referenced standard/guideline/criteria
ppT= parts per thousand
mS/cm= milliSiemens per centimeter
***** Total fecal coliform (includes E. Coli)
****** applies to freshwater surface water
******* Except as due to natural conditions, nutrients shall not be allowed in concentrations that render the waters unsuitable for the existing or designated uses
NS= No sample collected
NA= Not analyzed for
ND= Dissolved oxygen not detected by the analytical method
<= Not detected at the given detection limit
DENR= Philippine Dept of Environment and Natural Resources
USEPA= U.S. Environmental Protection Agency
NJDOH/NJDEP= New Jersey Dept of Health/ New Jersey Dept of Environmental Protection
GES= General Effluent Standards, Class SB Coastal Waters (DENR, DAO 2016-08/DAO 2021-19, regulatory); applies to point sources of pollution
WQG= Water Quality Guidelines; for water quality management purposes, Class SB Coastal Waters (DENR, DAO 2016-08/DAO 2021-19, not intended for enforcement)
RWQC= Recreational Water Quality Criteria (USEPA, recommended criteria, geometric mean, updated 2012)
SCWQS= Sanitary Code Water Quality Standards (NJDOH, regulatory, for bathing beaches)
SWQS= Surface Water Quality Standards (NJDEP, regulatory); for saline coastal (SC) waters unless otherwise indicated

Fish Abundance and Diversity

Due to poor visibility in the offshore waters during the 2023 sampling event, an underwater survey was conducted only in 2022. About 14 fish species (7 families) were documented in the adjacent (nearshore) seagrass beds and coral patches east of the Piapi Beach area. (See Appendix for photos.) Fish biomass and population density were notably low at 1.29±0.5(SE) kg/500m² and 152±82(SE) individuals/500m², respectively, based on the transects established in the seagrass beds. The most likely cause of such low biomass and fish density is pollution of the shallow marine waters, including microplastic ingestion. Similarly, in the shallow seagrass beds of the Banilad MPA, fish biomass was also very low at 1.3 kg/500m² (SUAKCREM, unpublished data). The deeper portions of the area (i.e., coral reefs) still harbor a considerable number of fish diversity and higher biomass (especially the Bantayan MPA), which in 2012 survey had an estimated total biomass of ~3.43 kg/500m² (SUAKCREM, unpublished report). Still, this figure can be considered lower than other well-protected and unpolluted seagrass beds. For example, based on a survey conducted by SUAKCREM in 2018, the shallow seagrass beds inside the unpolluted cove in Cantaan, Camiguin Island, had an estimated fish biomass of 17 kg/500m².

Another notable observation was the presence of schooling juveniles of rabbitfishes (e.g., Siganus spinus and S. fuscescens; see photos, Fig. 12K and 12R in the Appendix) in the study area. Rabbitfishes have been noted to be tolerant to changes in temperature and salinity (Seale & Ellis, 2019). Therefore, they may be adapting to pollution in the study area where elevated parameters such as temperature, TSS, ammonia, and bacteria were found.

Discussion

Tables 3 and 4 summarize the analytical results of the first (2022) and second (2023) rounds of sampling. The values were compared to various regulatory limits that include standards (enforceable) and criteria and guidelines (non-enforceable). These were obtained from the Philippine Department of Environment and Natural Resources (DENR) regulations (standards and guidelines), U.S. Environmental Protection Agency (USEPA) regulations (recommended criteria only), and standards used in the state of New Jersey (New Jersey Department of Health, DOH, and New Jersey Department of Environmental Protection, NJDEP) that apply to surface water and bathing beaches in the state. Since the USEPA only provides recommendations for criteria in recreational waters, the New Jersey

standards are presented herein considering that this state hosts numerous public beaches which are visited by tens of millions (48 million in 2018) of beachgoers each summer (Petenko, 2019) and are strictly monitored by the state for bacteria levels. Daily monitoring by the State of New Jersey occasionally results in the temporary closure of beaches whenever the applicable standards are exceeded.

Only the DENR standards might be enforceable in the study area. The DENR guidelines are recommendations. The listed limits of the USEPA and the State of New Jersey are not enforceable in the study area. However, they are considered the best alternative standards and criteria to evaluate the parameters or contaminants vis-à-vis the protection of human health and aquatic organisms as scientifically established by such institutions.

The following explains the referenced limits used in this study and listed in the tabulations of sampling results (Tables 1 and 2):

- GES= General Effluent Standards; Class SB waters (DENR, DAO 2016-08/DAO 2021-19, regulatory and enforceable); applies to point sources of pollution impacting Class SB marine waters (for protection of fisheries, tourism, recreational activities)
- WQG= Water Quality Guidelines; for water quality management purposes; protection of Class SB marine waters; (DENR, DAO 2016-08/DAO 2021-19); recommendations only, not intended for enforcement
- RWQC= Recreational Water Quality Criteria (USEPA, recommended criteria, geometric mean, updated 2012); applies to human health protection in coastal and non-coastal recreational areas
- SCWQS= Sanitary Code Water Quality Standard (NJDOH, regulatory; for bathing beaches)
- SWQS= Surface Water Quality Standards (NJDEP, regulatory) for saline coastal (SC) waters; protection of shellfish, ecology, and human health in recreational activities

Temperature and pH

The NJDEP-SWQS specifies "No thermal alterations which would cause temperatures to exceed 26.7 degrees Celsius (80°F) Summer seasonal average"; however, such standard for temperate locations like much of the U.S. would not apply in tropical Philippines where natural temperatures are higher. The DENR-WQG is listed as ranging from 26 to 30°C, but further

states: "The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment." The average offshore temperature readings at the sampling stations were consistently 30.8°C in 2022 and 2023. This slightly exceeds the maximum value of the DENR-WQG (30°C) and suggests climate change. However, seasonal variability may also be a factor in this case; thus, a long-term study would be necessary to address such postulation.

Except for one sample, all the measured pH levels from the outfalls and the offshore seawater were within the applicable DENR-GES (pH at 6.5 to 9) and WQG (pH at 7.0 to 8.5). The exception was the sample from Outfall Station 4, which had a pH of 5.39, indicating slightly acidic conditions in June 2023. Such exceedance was associated with significant contamination, as supported by the sample's highest BOD and bacteria levels among all the samples.

Conductivity and Salinity

No applicable standards and criteria were noted for conductivity and salinity. The elevated levels of these parameters at outfall Stations 6 and 7 were related to elevated chloride and TDS levels. Conductivity at these two stations ranged from 15.93 to more than 19.99 milliSiemens per centimeter (mS/cm), while conductivity at the other stations ranged only from 0.42 to 2.26 mS/cm. Salinity at Stations 6 and 7 was either 19 or 20 parts per thousand (ppt) in the two sampling rounds, while the other 5 stations registered zero salinity. (Typical seawater has a salinity of around 35 ppt.) The data suggests the influence of saltwater intrusion into the shallow groundwater and sewer pipes at Stations 6 and 7 (e.g., leaky pipes or entrance of salt water into the pipes and permeable soils during pre-sampling high tides).

Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD)

All DO results for the outfall samples failed the DENR standard since the measured DO values, which ranged from non-detect (ND) to 5.96 mg/L, were low during both rounds of sampling. The DENR specifies a GES (standard) of ≥ 6 mg/L (minimum), while the NJDEP has a SWQS of ≥ 5 mg/L (minimum). Such low DO values in the samples from the study area indicated significant contamination of the effluent.

On the other hand, all offshore (seawater) samples except those from

two stations (Station 7, DO=4.91 mg/L in 2022 and Station 1, DO=5.43 mg/L in 2023) had acceptable values ranging from 6.21 to 8.43 mg/L. Such levels complied with the DENR standard of 6 mg/L (minimum limit). The low DO at Station 7 was likely due to the relatively high concentration of enterococci, but the possible cause for lower DO at Station 1 is unknown (bacteria and nutrient levels were relatively low); it is possible that elevated oil and grease, which were not analyzed for, may have been present in the sample and had influenced such lower DO value.

No standards or criteria were available to compare the BOD levels in the offshore (seawater) samples. Outfall samples from Stations 2, 3, 4, and 5 exhibited elevated BOD levels that failed the DENR-GES of 30 mg/L. BOD concentrations ranged from 54.55 to 635.30 mg/L. The low DO and high BOD combination further indicated the presence of contamination (i.e., consumption of oxygen by bacteria and nutrients) in the effluent.

Oil and Grease, and Total Dissolved Solids (TDS)

Only one round of sampling for oil and grease was performed for this study due to issues with the unavailability of lab materials. Analysis was performed only on the first round of samples from the outfall stations. The analytical results were compared to the DENR-GES of 5 mg/L for oil-and-grease (The NJDEP-SWQS only specifies a qualitative standard of "non-noticeable.") The samples from Station 4 and Station 5 had concentrations of 8.8 and 8.6 mg/L, respectively, which were above the DENR-GES standard. This indicated that oil and grease contaminants were contributing to the pollution of the study area. The other five samples had concentrations that ranged from <2 to 4.4 mg/L, below the numerical standard of the DENR. Oil and grease components include waste cooking oils and petroleum oils and consist of the major types of compounds: oils, fats, and waxes. These, in turn, include many types of chemicals, including those occurring in petroleum-based waste oils or used oils. Waste or used oils may contain toxic benzene, polynuclear aromatic hydrocarbons, PCBs, and heavy metals (USEPA, 2018; Lulek,1998; CalEPA, 2021).

Only the outfall samples were analyzed for TDS during the two rounds of sampling. No standards or criteria were available for regulatory comparison of the results. However, a clear trend was noted from the results: two stations (6 and 7) had TDS concentrations (ranging from 16,966 to 20,815 mg/L) that were at least an order of magnitude higher than the rest. The results for conductivity, DO, salinity, chloride, and flow rates further differentiated the physico-chemical and hydrologic conditions at Stations 6

and 7 from the rest of the sampling stations.

Total Suspended Solids (TSS) and Chloride

The DENR-GES (applicable to point sources, e.g., the outfall sampling points in the study area) for TSS is 70 mg/L, while the WQG (applicable to the offshore samples) for TSS is 50 mg/L. The NJDEP-SWQS has a qualitative (narrative) standard for TSS in surface water: it must be suitable for various uses of the coastal waters, including tourism, recreation, ecology, and fisheries.

The results for the first sampling event (2022) showed that only one station (7) had a TSS level (96 mg/L) exceeding the DENR-GES of 70 mg/L. The offshore samples, however, indicated that four stations (1, 2, 6, and 7) had TSS (ranging from 63 to 115 mg/L) exceeding the DENR-WQG of 50 mg/L. The analytical results for the 2023 outfall sample from Station 4 indicated a TSS level of 131 mg/L, which exceeded the DENR-GES of 70 mg/L. The offshore sample from Station 7 had TSS at 75 mg/L, which exceeded the DENR-WQG by 50 mg/L. TSS was high at the offshore sampling point of Station 1 (Mojon Creek) and the offshore sampling points for Stations 2, 6, and 7. High TSS levels at the mouth of Mojon Creek are understandably due to turbidity and the suspended load carried by the creek (see photo in Fig. 2A). The TSS levels at the offshore sampling points may be due to the combination of suspended solids from sewage and from sediments associated with natural beach processes. Further study is needed to distinguish the sources of such suspended particles.

Due to the saline nature of the coastal waters in the study area, there are no applicable regulatory limits for chloride. The analytical results for the outfall samples indicated higher chloride levels (ranging from 9,510.8 to 11,682.9 mg/L) at Stations 6 and 7, with concentrations that were two orders of magnitude higher than those from the other stations (chloride levels ranging from 23.4 to 496.93 mg/L). As discussed in the previous sections above, other parameters at Stations 6 and 7, including salinity, DO, TDS, and flow rates, suggested different physico-chemical and hydrologic conditions compared to the other sampling stations. Those conditions may partly be related to saltwater intrusion (into the soils and pipes) and the high permeability of soils at those locations.

Phosphate

The DENR-GES for phosphate is 2 mg of phosphate-phosphorous

per liter (mg PO_4-P/L), while the DENR-WQG is 0.20 mg PO_4-P/L. Only minor exceedance was indicated by the sampling results. In the first sampling event (2022), Station 5 had 3.77 mg PO_4-P/L in the outfall effluent, exceeding the DENR-GES. Meanwhile, Station 6 had 0.26 mg PO_4-P/L in the offshore seawater sample, slightly exceeding the DENR-WQG. All other phosphate results were below the DENR limits. No exceedances were noted in the second round of sampling (2023). Elevated phosphate levels in sewer and surface water are typically attributable to contamination from domestic and commercial wastewater (e.g., waste food, detergents, and soaps).

Ammonia, Nitrate, and Nitrite

Ammonia, nitrate, and nitrite are common nutrients in polluted waters and were all detected in the samples collected from the study area. The DENR-GES for ammonia at point sources is 3 mg of ammonia-nitrogen per liter (mg NH_3-N/L). The DENR-WQG for ammonia is a low 0.06 mg NH_3-N/L. For further comparison to international limits, the NJDEP-SWQS for ammonia consists of acute (0.094 mg NH_3-N/L) and chronic (0.024 mg NH_3-N/L) standards, which consider the protection of aquatic organisms.

The analytical results for the study area show that all outfall sampling results from the two sampling rounds exceeded the DENR-WQG and the NJDEP-SWQS for ammonia. The ammonia levels ranged from 0.32 to 15.02 mg NH_3-N/L. Furthermore, outfall Stations 3, 4, 5, and 7 had ammonia levels that exceeded the DENR-GES of 3 mg NH_3-N/L during at least one sampling event. For the offshore samples, concentrations ranged from 0.046 to 0.39 mg NH_3-N/L. All offshore samples exceeded the NJDEP-SWQS (acute/chronic effects) of 0.094/0.024 mg NH_3-N/L. And the DENR-WQG of 0.06 mg NH_3-N/L during at least one sampling event. All this data suggests that ammonia contamination in the outfall effluent and offshore waters is a concern for toxicity to marine organisms. Ammonia is a well-known and common contaminant in the environment, originating from sewage, cleaning compounds, decomposing organic matter, animal wastes, fertilizers, microbial activity, etc.

No applicable standards or criteria are available for nitrite (NO_2) concentrations. The DENR's WQG and GES for nitrate (NO_3) are 10 and 20 mg N/L, respectively. No sample from the study area exceeded these limits. Nitrite (NO_2) and nitrate (NO_3) were detected in the outfall and offshore sampling points samples. NO_2 concentrations ranged from 0.002 to 0.150 mg of nitrite-nitrogen per liter (mg NO_2-N/L). NO_3+NO_2 concentrations ranged from 0.012 to 0.935 mg of total nitrogen per liter (NO_3+NO_2 mg

N/L). It can be noted that the highest levels of nitrate and nitrite were detected at Station 1 (mouth of Mojon Creek). This is consistent with the creek's higher flow rate and length than the sewer lines associated with the other sampling stations (outfalls). Nitrogen compounds as contaminants have numerous upstream potential sources (e.g., domestic and agricultural wastewaters, leaking septic tanks and sewer pipes, gray water discharge into ditches and creeks, golf courses, and agricultural surface runoff and groundwater discharge) contributing to Mojon Creek contamination as it makes its way toward Silliman Beach.

E. coli and Enterococci Bacteria

Fecal contaminants are responsible for over 150 million cases annually of gastrointestinal and respiratory illnesses in coastal bathers and beachgoers around the world. Epidemiological studies concluded that E. coli and enterococci can be considered "indicator bacteria" for monitoring fresh and marine waters to protect human health (Halliday & Gast, 2011). When present at high levels in polluted waters, these fecal bacteria may cause illnesses. The elderly, children and those with weakened immune systems are at higher risk (Massachusetts Department of Health, 2024). The following are typical symptoms of illnesses:

- Gastrointestinal symptoms – nausea, vomiting, diarrhea, and abdominal pain
- Respiratory symptoms – sore throat, cough, runny nose, and sneezing
- Dermatological symptoms – skin rash and itching
- Eye and ear symptoms – irritation, earache, itching
- Flu-like symptoms – fever and chills

Although sandy media was not sampled for this study, beach sands under certain conditions favor the growth of enterococci bacteria (Yamahara et al., 2009) and, therefore, pose health risks for beachgoers in contact with the sand. This includes the ubiquitous pet dogs that commonly accompany human beachgoers at Silliman Beach.

For this study area in Bantayan and Piapi, the analytical results for *E. coli* and enterococci indicated extremely high pollution levels at the outfall and offshore sampling points. The DENR's GES and WQG for total fecal coliform (including *E. coli*) are 200 colony-forming units per 100 ml (CFU/100 ml) and 100 CFU/100 ml, respectively. The USEPA recommends

an RWQC for *E. coli* (126 CFU/100 ml) in freshwater, which differs from that of enterococci (35 CFU/100 ml) in either freshwater or marine water. Due to the ability of enterococci to tolerate saline water (Byappanahalli et al., 2012), New Jersey (as well as many other coastal states and other international regulatory agencies) specifies the monitoring of coastal waters and beaches for enterococci, with a Sanitary Code-Water Quality Standard of 104 CFU/100 ml and a 30-day geometric mean (GM) limit of 30 CFU/100 ml (which is also the NJDEP's Surface Water Quality Standard for saline coastal waters).

The *E. coli* results for the outfall samples in both the first and second rounds of sampling exceeded all the referenced standards and criteria and ranged from 4,600 to 47,200,000 CFU/100 ml. Compared to the regulatory (GES) and recommended (WQG) limits of the DENR, the highest *E. coli* concentrations detected in Stations 3, 4, and 5 were five orders of magnitude higher. The *E. coli* concentrations in the offshore samples were lower (ranging from 200 to 25,500 CFU/100 ml) as might be expected for this saline-intolerant bacterium, but all results of the first and second sampling rounds still exceeded the referenced standards and criteria (except for that of Station 3 which had the lowest *E. coli* concentration of 200 CFU/100 ml).

All enterococci results for the outfall samples in both the first and second rounds of sampling also exceeded the referenced standards and criteria and ranged from 2,500 to 51,625,000 CFU/100 ml, or up to five orders of magnitude higher. All the offshore samples in the first and second rounds of sampling had lower levels than those of the outfall samples, but they greatly exceeded the referenced standards and criteria (by one to twoorders of magnitude). These seawater samples had enterococci concentrations ranging from 1,600 to 28,900 CFU/100 ml. *E. coli* in the study area appears unusually tolerant to saline waters. Further studies that consider spatial and temporal variability and comparisons of the survivability of enterococci versus *E. coli* in seawater might shed light on these two types of bacteria.

Impact of Pollution on Fish Population and Biomass

This study focused on sewer-discharge pollution by bacteria and physico-chemical parameters including nutrient pollutants, and their impact on human health and marine organisms. Evaluation was based on established standards and recommended effluent and surface water criteria. The impact on fish biomass and population density was also conducted as a supplementary part of the project. This included microplastic quantification in the fish gut (discussed in the next section below).

Nitrogen contamination (e.g., from elevated ammonia levels) in the study area is most likely a significant cause of low or decreasing fish biomass; however, a long-term study would be needed to obtain data on seasonal variability. Ammonia can cause significant fish mortalities as they actively absorb the chemical through their gills (Stotton, 2023). Ammonia toxicity to fish has been documented and widely studied (Eddy, 1999). In West Hawaii, the impact of nitrogen compounds in the marine environment from sewage pollution was found to cause the most negative impact (among other impacts) on fish biomass, based on a 10-year study on pollution sources and fish biomass (Foo et al., 2021). Their study found an overall fish biomass decrease of 45% (with more than 50% for certain types of fish) in polluted waters due to nitrogen contamination. Nitrogen sources in their study included golf courses and land-based sewer discharges. It is well established that excess nitrogen and phosphorous in water bodies can lead to excessive growth of algae, which, when it dies, decays and uses up valuable oxygen. Algae also competes with seagrasses for light, which leads to the loss of seagrasses (further depleting a food source for fish) and leading to illness and death of fish (NOAA, 2024; EPA, 2024).

TSS is another parameter likely impacting fish population and biomass in the study area. The average TSS in offshore samples was 59.3 mg/L in 2022, above the DENR-WQG value of 50 mg/L. TSS is an indication of water turbidity and pollution. Such impact on water quality may result in physiological and behavioral effects, including disruptions in migrations and spawning, movement patterns, disease susceptibility, growth and development, reduced hatching success, and death. TSS impact on fish depends on other variables, including fish species, temperature, duration and frequency of exposure, and sediment type (Kjelland et al., 2015). A long-term study of TSS and turbidity and a few other parameters is recommended in the study area better to understand their impact on the fish population and biomass.

Bacteria (*E. coli* and enterococci) levels detected in the study area were extremely high at the offshore sampling stations and orders of magnitude higher at the outfalls. Such contamination is most likely a significant factor in the low fish population and biomass noted in the study area. Kumari (2020) reports on bacterial diseases caused by several bacteria types in marine fishes, including enterococci. Bacterial diseases are commonly associated with organic pollutants and reduced DO in the water. Symptoms and illnesses in fish included weakening natural resistance to environmental stress, columnaris infection, vibriosi infection, flexibacteriosis of the gills, etc. Tenacibaculosis is an ulcerative illness with symptoms of tail rot, superficial ulcerations, mouth erosion, and fin necrosis (Mabrok et

al., 2023). Experiments on the effects of enterococcus infection on tilapia were reported by Zahran et al. (2019); effects included high mortality and abnormalities like anorexia, detached scales, exophthalmia, pale gills, friable liver, kidney congestion, enlarged gall bladder, etc.

Other Data (Microplastics in Fish Guts, Organic Chemical Contaminants)

A study coordinated by A. Bucol of SUAKCREM in collaboration with biology students from NORSU (sampling was conducted at the same time as the physico-chemical and bacteriological sampling event in 2022) quantified the microplastic contents in the guts of a fish species *Halichoeres scapularis* (Zigzag Wrasse) in the study area (A. Bucol, personal communication, February 2024). The results revealed a low microplastic occurrence of 14.29% (5 fish out of the 35 samples) and a density of 0.14 items per fish (Banagudos & Triplitt, 2023, unpub. thesis). Previous studies conducted in 2020 on the microplastics from the rabbitfish Siganus fuscescens samples caught by fishers in our study area (Bucol et al., 2020; Alcala et al., 2022) showed that microplastic occurrence was higher (39% out of 90 samples) with a corresponding density of 0.67–0.87 microplastic particles per fish. Bucol et al. (2020) reported an average of 12.3 particles per 150 g dry weight of intertidal sediment samples (n=15) along Silliman Beach. The difference between the microplastic occurrence and density in 2020 versus that of 2022 may be due to several factors, including seasonal variation and differences in the feeding biology of the two fish species: *Halichoeres scapularis* are invertivore while siganids are benthic herbivores.

The effects of microplastics on fish have been getting much attention from researchers in the past decade. Two significant works involving experiments on feeding fish with microplastics of varying sizes, types, or feeding frequency are Critchell and Hoogenboom (2018) and Naidoo and Glassom (2019). Results included mortality and adverse effects on physiology and growth.

A previous research collaboration between SUAKCREM and Arizona State University in 2021 involved a study of persistent organic pollutants (POPs) in fish. Their results showed that out of the 30 samples of *S. fuscescens* from the Silliman Beach area, almost all (29) were contaminated by phthalates and polyaromatic hydrocarbons (PAHs); furthermore, 15 samples were contaminated by pesticides, and 11 by PCBs (Molina et al., 2021). Such organic chemical contamination in the study area has not been previously reported.

Conclusions

• Contamination in the study area is characterized by extremely high levels of *E. coli* and enterococci bacteria originating from the Mojon Creek and outfall pipes along the seawall. They pose a risk of human health issues such as dermatological, gastrointestinal, and respiratory illnesses in beach bathers, swimmers, and people and their pets in contact with beach sand or sediments. The two sampling rounds represent worst-case levels of contamination that typically occur during and a few days of rainstorms. Bacterial contamination may also be a significant factor in low fish biomass in the shallow seagrass beds in the study area. Potential sources of fecal bacteria include domestic and commercial wastewaters, leaking septic tanks, animal waste, food preparation and disposal, and as part of natural biota in soils and surface water.

• *E. coli* concentrations were as high as 47.2 million CFU/100 ml in effluent water at the outfalls and 25,500 CFU/100 ml in offshore seawater. These were orders of magnitude higher than the DENR's General Effluent Standards or GES (200 CFU/100 ml) and Water Quality Guidelines or WQG (100 CFU/100 ml) for total coliform.

• Enterococci concentrations were as high as 51.6 million CFU/100 ml in effluent water at the outfalls and 28,900 CFU/100 ml in offshore seawater. These were also orders of magnitude higher than the referenced standards and criteria. Since the DENR does not specify any standards for enterococci, the sampling results were compared to existing USEPA recommended exposure limits (Recreational Water Quality Criteria, 35 CFU/100 ml) and the New Jersey Surface Water Quality Standards or SWQS (30 CFU/100 ml) and Sanitary Code Water Quality Standards (104 CFU/100 ml, specifically for recreational beaches).

• Bacteriological contamination was accompanied by high levels of ammonia and BOD and low levels of DO (some samples had non-detect DO). At least four outfalls had ammonia levels (up to 15.017 mg NH_3-N per liter) significantly exceeding the DENR's GES (3 mg NH_3-N per liter). This further indicated high levels of contamination in the effluent.

• Ammonia levels in the offshore samples were as high as 0.39 mg NH_3-N/L, which exceeded the DENR's WQG of 0.06 mg NH_3-N/L as well as the NJDEP's 0.09/0.024 mg NH_3-N/L for acute/chronic SWQS. Sources of ammonia and ammonium contamination typically

include effluent from domestic wastewater, agricultural activities (e.g., application of fertilizers), leaky septic tanks, and vehicular emissions. The monitoring and regulating of ammonia levels are mainly done to protect aquatic organisms. The elevated ammonia and nitrogen levels in the study area may also be a significant factor in the low fish population and biomass.

• Two outfall samples (from Stations 4 and 5) indicated elevated oil and grease concentrations (8.8 and 8.6 mg/L, respectively), which exceeded the DENR's GES of 5 mg/L. There are various potential sources of oil and grease, including vehicle maintenance and repair discharges, oil spills on roadways, and deliberate discharge of used or waste oils into the sewer system. Waste or used oils may contain individual chemicals that are toxic to humans or aquatic organisms. Such chemicals may include organic compounds (e.g., benzene, polynuclear aromatic hydrocarbons, or PCBs) and heavy metals.

• Plastics and other garbage debris were noted on the seabed offshore of Silliman Beach, discharging from the mouth of Mojon Creek and some sewer outfalls. These are all contributing to the pollution of the study area.

• Aside from physico-chemical and bacteriological contamination, microplastic contamination was documented from a collaborative investigation involving microplastics in fish guts. Microplastic ingestion by fish is likely another significant factor contributingto the study area's low population and fish biomass. Furthermore, pollution may not be limited to the contaminants addressed in this study. Based on a previous study by others on organic chemical analysis of fish specimens collected from the area, there is a possibility that other contaminants may have discharged or continue to be discharging into the marine waters of the study area, including phthalates, polynuclear aromatic hydrocarbons, pesticides, and PCBs.

Recommendations

• Higher frequency of bacteriological monitoring, e.g., daily or weekly bacteriological testing of beach waters, especially during the summer months, public holidays, scheduled electrical power outage days, and weekends during non-summer months

• Extension of the study area southwards to include other parts of the City's coastline where the public uses beaches for recreation

• Sampling of beach sands or sediments for bacteriological and

chemical analyses for selected heavy metals, PCBs, pesticides, and semi-volatile organic compounds

- Long-term studies on physico-chemical parameters, fish population, biomass, and microplastics in fish gut consider spatial and seasonal variability and variability in microplastic consumption by different fish species.
- Planning and implementation of a public warning system at the beaches and implementation of beach closure on days when dangerous bacteriological levels are detected
- Design and construction of debris (including plastics) interception or screening system at the mouth of Mojon Creek
- Design and implementation of a comprehensive environmental assessment and river basin master plan for the Mojon Creek and its tributaries
- Enforcement of existing ordinances on trash disposal at beaches and illegal discharges into the sewer system or adoption of new ordinances if existing ones do not adequately address the issues
- Requiring (or enforcing existing regulations on) sediment traps, grease traps, or oil-water separators for industrial facilities, vehicle repair stations, hotels, apartments, condominiums, restaurants, and commercial parking lots

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REFERENCES

Alcala, A. C., Bucol, A. A., Bucol, L. A., Romano, E. F., Cabcaban, S., Alvarez, G. A. A., Ruben, Z., Bachner, M., Bird, C., Polidoro, B. A., & Carpenter, K. E. (2022). Microplastics in the mottled rabbitfish (Siganus fuscescens) in Negros Oriental, Philippines with notes on the Siganid fishery. *Silliman Journal, 61*(1). https://sillimanjournal.su.edu.ph/index.php/sj/article/view/24

Alcala, M.L.(2002). *Coastal processes and protection: a geological perspective.* [Powerpoint slides]. Silliman University Founder's Day Balik Talent lecture series, SU Audio-Visual Theater, Dumaguete City, Philippines, April 15, 2002. (PPT slides submitted to SUAKCREM, Silliman University.)

Allen, G.R. & Erdmann, M.V. (2012). *Reef fishes of the East Indies* (Vol I–III). University of Hawai'i Press. https://doi.org/10.1111/jfb.12248

Banagudos, J.K.G. & Triplitt, M.V. (2023). *Percent occurrence and abundance of microplastics in zigzagwrasse (Halichoeres scapularis) from selected coastal areas in Central Visayas, Philippines* [Unpublished senior thesis]. Negros Oriental State University, Philippines.

Barboza, T. (2014, March 7). *Three days after rain, beach water can still make swimmers ill, study says.* UCLA Institute of the Environment & Sustainability website [online article]. https://www.ioes.ucla.edu/news/3-days-rain-beach-water-can-still-make-swimmers-ill-study-says

Bucol, L. A., Romano, E. F., Cabcaban, S. M., Siplon, L. M. D., Madrid, G. C., Bucol, A. A., & Polidoro, B. (2020). Microplastics in marine sediments and rabbitfish (Siganus fuscescens) from selected coastal areas of Negros Oriental, Philippines. *Marine Pollution Bulletin, 150*, 110685. https://doi.org/10.1016/j.marpolbul.2019.110685

Byappanahalli, M.N., Nevers, M.B., Korajkic, A., Staley, Z.R., & Harwood, V.J. (2012). Enterococci in the environment. *Microbiology and Molecular Biology Reviews, 76* (4), 685–706. https://doi.org/10.1128/mmbr.00023-12

Critchell, K., & Hoogenboom, M. O. (2018). Effects of microplastic exposure on the body condition and behaviour of planktivorous reef fish *(Acanthochromis polyacanthus). PLoS One.*https://doi.org/10.1371/journal.pone.0193308

Department of Environment and Natural Resources, DENR (2016). Water quality guidelines and general effluent standards of 2016. DENR Administrative Code No. 2016-08. https://emb.gov.ph/wp-content/uploads/2019/04/DAO-2016-08_WATER-QUALITY-GUIDELINES-AND-GENERAL-EFFLUENT-STANDARDS.pdf

Department of Environment and Natural Resources, DENR (2021). Updated Water Quality Guidelines (WQG) and General Effluent Standards (GES) for selected parameters. DENR Administrative Code No. 2021-19. https://ncr.denr.gov.ph/images/dao-2021-19-updated-water-quality-guidelines-wqg-and-general-ef_p21757.pdf

Eddy, F. B. (1999). Effects of ammonia on fish and responses of the ionic regulatory system. In A. K. Mittal, F.B. Eddy, & J.S. Datta Munshi (Eds.), *Water/Air transitions in Biology* (pp. 281–292). Oxford and IHB. https://www.researchgate.net/publication/315586954_Effects_of_ammonia_on_fish_and_responses_of_the_ionic_regulatory_system

Foo, S.A., Walsh, W.J., Lecky, J., Marcoux, S., & Asner, G.P. (2020). Impacts of pollution, fishing pressure, and reef rugosity on resource fish biomass in West Hawaii. *Ecological Applications, 31* (1). Ecological Society of America. DOI: 10.1002/eap.2213

Halliday, E., & Gast, R.J. (2011). Bacteria in beach sands: an emerging challenge in protecting coastal water quality and bather health. *Environmental Science & Technology, 45* (2), 370–379. https://doi.org/10.1021/es102747s

Kaczmarsky, L., & Richardson, L. L. (2011). Do elevated nutrients and organic carbon on Philippine reefs increase the prevalence of coral disease? *Coral Reefs, 30,* 253–257. https://link.springer.com/article/10.1007/s00338-010-0686-2

Kjelland, M.E., Woodley, C.M., Swannack, T.M., & Smith, D.L. (2015). A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. *Environment Systems and Decisions, 35*, 334–350. https://doi.org/10.1007/s10669-015-9557-2

Kumari, S. (2020). Freshwater and marine water fish diseases: A review. *International Journal of Fisheries and Aquatic Studies, 8* (4), 65-68. https://www.fisheriesjournal.com/archives/2020/vol8issue4/PartA/8-4-86-558.pdf

Lulek, J. (1998). Levels of polychlorinated biphenyls in some waste motor and transformer oils from Poland. *Chemosphere, 37* (9-12), 2021—2030.https://doi.org/10.1016/S0045-6535(98)00266-5

Mabrok, M., Algammal, A.M., Sivaramasamy, E, Hetta, H.F., Atwah, B., Alghamdi, S., Fawzy, A, Avendano-Herrera, R., & Rodkhum, C. (2023). Tenacibaculosis caused by Tenacibaculum maritimum: Updated knowledge of this marine bacterial fish pathogen. *Frontiers in Cellular and Infection Microbiology, 12*. https://doi.org/10.3389/fcimb.2022.1068000

Massachusetts Department of Public Health. (2024). *Frequently asked questions about monitoring water quality at beaches.* Official website of the State of Massachusetts. https://www.mass.gov/info-details/frequently-asked-questions-about-monitoring-water-quality-at-beaches#what-are-the-risks-associated-with-bacteria-in-beach-water?

Molina, E., Polidoro, B., & Bucol, L. (2021). *Contaminants in Philippine fish (Siganus fuscescens) and potential effects on public health.* [BSc thesis, Arizona State University, Barrett, The Honors College Thesis/Creative Project Collection]. https://keep.lib.asu.edu/items/147908

Naidoo, T. & Glassom, D. (2019). Decreased growth and survival in small juvenile fish, after chronic exposure to environmentally relevant concentrations of microplastic. *Marine Pollution Bulletin, 145*, 254-259. DOI: 10.1016/j.marpolbul.2019.02.037

New Jersey Department of Health, NJDOH. (2018). *Public recreational bathing.* Sanitary Code, Chapter 9. NJ Administrative Code NJAC 8:26. Last readopted January 16, 2018. https://www.nj.gov/health/ceohs/documents/phss/recbathing.pdf

New Jersey Department of Environmental Protection, NJDEP. (2023). *Surface Water Quality Standards.* NJ Administrative Code NJAC 7:9B. Readopted July 17, 2023, last amended December 18, 2023. https://dep.nj.gov/wp-content/uploads/rules/rules/njac7_9b.pdf

NOAA (2024). What is nutrient pollution? *National Ocean Service Website.* https://oceanservice.noaa.gov/facts/nutpollution.html, updated 06/16/24.

Petenko, E. (2019, August 1). How many beachgoers visit the Jersey Shore? We flew over it to find out. *NJ.com.* https://www.nj.com/news/g66l-2019/08/80df18bd046430/how-many-beachgoers-visit-the-jersey-shore-we-flew-over-it-to-find-out.html

Seale, A.P., & Ellis, S. (2019). Sustainable capture-based aquaculture of rabbitfish in Pacific island lagoons. *Aquaculture and Aquaponics* (published by the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, July 2019), AA-1, 1–9. https://www.ctahr.hawaii.edu/oc/freepubs/pdf/AA-1.pdf

Stotton, S.F. (2023, March 9). *Quantifying the environmental impacts of ammonia at sea.* Ammonia Energy Association. [Online article].https://ammoniaenergy.org/articles/quantifying-the-environmental-impacts-of-ammonia-at-sea/

USEPA. (2012). Recreational water quality criteria. Last revised 2012. Office of Water Document #820-F-12-058. https://www.epa.gov/sites/default/files/2015-10/documents/rwqc2012.pdf

USEPA. (2018). Fact sheet: Preventing and detecting PCB contamination in used oil (February 2018). USEPA website. https://www.epa.gov/pcbs/fact-sheet-preventing-and-detecting-pcb-contamination-used-oil

USEPA (2020). Standard Operating Procedures: Wastewater flow measurement (LSASDPROC-109-R5). *EPA.gov.* https://www.epa.gov/sites/default/files/2015-10/documents/wastewater_flow_measurement109_af.r4.pdf

USEPA (2024). Nutrient pollution, the problem. *USEPA Website.* https://www.epa.gov/nutrientpollution/problem. updated April 23, 2024.

Verdouw, H., Van Echteld, C. J. A., & Dekkers E.M.J. (1978). Ammonia determination based on indophenol formation with sodium salicylate. *Water Research, 12* (6), 399–402. https://doi.org/10.1016/0043-1354(78)90107-0

Yamahara, K.M., Walters, S.P., & Boehm, A.B. (2009). Growth of enterococci in unaltered, unseeded beach sands subjected to tidal wetting. *Applied Environmental Microbiology, 75* (6), 1517–1524. https://doi.org/10.1128/AEM.02278-08

Zahran E., Mahgoub H.A., Abdelhamid F., Sadeyen, J.R., & Risha, E. (2019). Experimental pathogenesis and host immune responses of Enterococcus faecalis infection in Nile tilapia *(Oreochromis niloticus). Aquaculture, 512* (15). https://doi.org/10.1016/j.aquaculture.2019.734319

APPENDIX A

SUMMARY OF RESULTS ON THE BACTERIOLOGICAL EXAMINATION OF WATER COLLECTED BY MS PAULINA ASPILLAS ON June 27, 2023

Sample (fresh water)	ETB medium*	EC medium*	Sample (sea water	ETB medium*	EC medium*
A1	228	196[a] 230[b] Total = 426	**B1**	16	0[a] 13[b]
A2 **(no sample)**			**B2**	27	36[a] 120[b] Total = 156
A3	56,000	12,000[a] 90,000[b] Total = 102,000	**B3**	120	57[a] 131[b] Total = 188
A4	300,000	52,000[a] 420,000[b] Total = 472,000	**B4**	122	25[a] 109[b] Total = 134
A5	162,000	46,000[a] 186,000[b] Total = 232,000	**B5**	168	37[a] 120[b] Total = 157
A6	25	0[a] 46[b]	**B6**	62	6[a] 34[b] Total = 40
A7	140	240[a] 175[b] Total = 415	**B7**	90	0[a] 46[b] Total = 46

*Values in CFU/ml
[a]*E. coli*
[b]coliform except *E. coli*
Total = Total coliform
EC= *E. coli*
ETB= enterococci bacteria

Samples prepared and analyzed in the lab by:

Socorro Parco, PhD

Date of analysis: June 27, 2023

APPENDIX B

SUMMARY OF RESULTS ON THE BACTERIOLOGICAL EXAMINATION OF WATER COLLECTED BY MS PAULINA ASPILLAS ON September 8, 2022

Sample (fresh water)	ETB medium*	EC medium*	Sample (sea water)	ETB medium*	EC medium*
A1	7,000	6,500[a]	**B1**	16	51[a] 325[b] Total=376
A2	101,000	8,500[a] 131,000[b] Total = 139,500	**B2**	88	15[a] 1110[b] Total = 125
A3	121,000	37,000[a] 122,500[b] Total = 159,500	**B3**	18	2[a] 60[b] Total = 62
A4	516,250	56,000[a] 340,000[b] Total = 396,000	**B4**	170	255[a] 225[b] Total = 477
A5	345,000	9250[a] 390,000[b] Total = 399,250	**B5**	289	15[a] 170[b] Total = 185
A6	1000	595[a] 27[b] Total = 622	**B6**	35	20[a] 50[B] Total = 70
A7	120	306[a] 4,500[b] Total = 4,806	**B7**	250	10[a] 120[b] Total = 130

*Values in CFU/ml
[a]*E. coli*
[b]coliform except *E. coli*
Total = Total coliform
EC= *E.coli*
ETB= enterococci bacteria

Samples prepared and analyzed in the lab by:

Socorro Parco, PhD

Date of analysis: September 9, 2022

APPENDIX C
Photos of Fish Species Observed and Identified in the Study Area

Figure 13A. Wrasse (*Sthetojulis interrupta*)

Figure 13B. *Halichoeres argus* (TP)

Figure 13C. *Parapercis cylindrica*

Figure 13D. *Salarias fasciatus*

Figure 13E. *Siganus spinus*

Figure 13F. *Ostorhinchus hartzfieldi* (left)
Sargocentron rubrum, Red Squirrelfish (right)

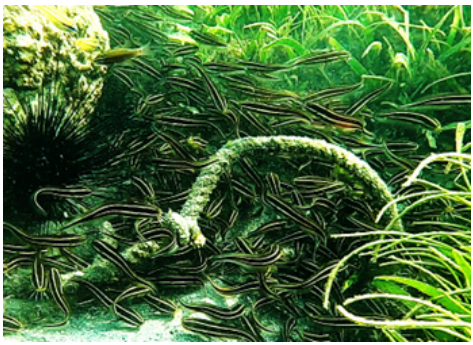

Figure 13G. *Plotosus lineatus* (shoaling)

Figure 13H. *Ostorhinchus cookii*

Figure 13I. *Pomacentrus tripunctatus* (Damselfishes, Pomacentridae)

Figure 13J. Assorted Cardinal fishes off Silliman Beach *(Ostorhinchus spp*.)

Figure 13K. *Ostorhinchus chrysopomus* (left) *Thalassoma hardwicke* (right)

Figure 13L. *Siganus fuscescens*

A Geochemical Investigation and Review of Hydrogeology of The Dumaguete Aquifer

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Abstract

The unconfined nature of the Dumaguete aquifer and urbanization with mixed agricultural-commercial-industrial uses pose risks of groundwater contamination. Upland geothermal waters and the absence of municipal sewage treatment and landfill facilities add to such risks. Other contaminant sources include hydrothermally-altered volcanic rocks, septic tanks, sewer pipes, sewage ditches, polluted creeks, and subsurface saltwater lenses.

A review of hydrogeology and a geochemical investigation of the aquifer were conducted for this study. Samples from six barangays (five wells and a spring) were analyzed for temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), salinity, arsenic, cadmium, lead, mercury, nitrate, chloride, phosphate, sulfate, and ammonium. Coliform analysis was added. Statistical evaluation included kriging to map contaminant concentrations. Supplementary TDS, EC, and salinity data were collected from 22 wells and springs.

Higher levels of pH, TDS, EC, salinity, and sulfate were found in the northeast section of the city, with TDS exceeding regulatory standards in barangay Bantayan. Arsenic was borderline in Daro and detected in Batinguel. Chloride in Calindagan was an outlier (although below regulatory levels); nitrate levels exceeded standards at four sites; phosphate exceeded standards at all sites. High coliform counts were detected at three sites. Five sites had low DO levels. Groundwater monitoring and modeling are warranted for the sustainability of the aquifer.

Keywords: Dumaguete aquifer, Dumaguete hydrogeology, Dumaguete environmental, groundwater pollution, Dumaguete groundwater, groundwater physico-chemical characteristics, Dumaguete drinking water

Introduction

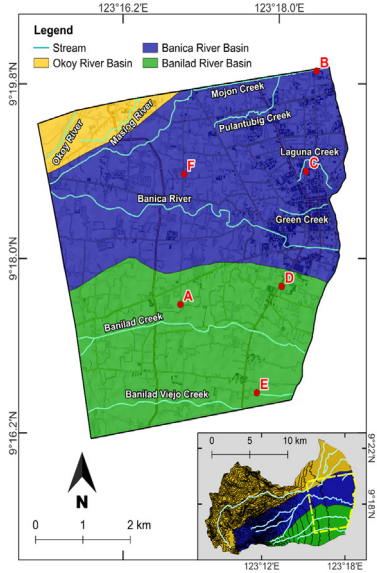
Background and Objectives

This paper was based on a senior thesis research conducted in 2023 and 2024 with partial funding from the Silliman University Angelo King Center for Research and Environmental Management (SUAKCREM). The main objectives were to characterize the Dumaguete aquifer via a review of the hydrogeology and groundwater sampling and to identify potential sources of contamination in the aquifer.

The term "geochemical investigation" is used herein to refer to the characterization of an aquifer based on natural chemical components and anthropogenic sources of potential pollutants. The term "Dumaguete aquifer" is defined herein to refer to the (>150-meter thick) unconfined aquifer that is the source of potable water in the municipality of Dumaguete. Such aquifer laterally extends into three adjacent municipalities and receives water from the Banica River basin, the Okoy River basin, and the Banilad River basin. The "Banilad River basin" is defined by two parallel creeks approximately 1.0 to 1.5 kilometers apart: the Banilad Creek and Banilad Viejo Creek. The three river basins cover Dumaguete and adjacent towns: Sibulan to the north, Valencia to the west, and Bacong to the south.

Figure 1

Map of the Dumaguete River Basins and Streams, Modified after SWECO/ LWUA (2001) and Emmanuel (2017)



Note: Sampling sites are shown as red dots. The inset shows the complete extent of the river basins. Yellow dashed lines indicate the extent of Dumaguete City—additional data from Open Topo Map, NAMRIA, SRTM, and Dumaguete City Engineering Office.

Risks of contamination by anthropogenic sources are due to rapid urbanization and the historical and current land uses, including agricultural (e.g., farming, livestock production, meat processing), commercial, and industrial operations such as quarrying, packaging, construction, chemical and petroleum storage and distribution, printing, gas service stations, and vehicle repair. Additionally, there is a risk of contamination from thousands of old, leaky septic and sewer systems since the city has no sewage treatment facility. Many of these systems are decades old and are likely discharging into the soils and underlying aquifer. Gray water is mainly combined and discharged with stormwater via underground pipes and ditches (lined, unlined, covered, and open) into surface water and outfalls along the coast. Furthermore, there is the risk of surface- and groundwater contamination from the geothermal field in the uplands west of the city. Lastly, there has been concern that the Dumaguete dumpsite may have generated leachate that has contaminated the groundwater. Thus, since the Dumaguete aquifer is unconfined and consists of permeable sediments, potential contamination from various sources poses health risks to the community.

Previous Works

In the past few decades, most aquifer investigations have involved bacteriological analyses with some physicochemical analyses of well water. The results were rarely publicized or published. Geochemical and environmental investigations, including sampling for metals and organic compounds, were rare and focused on the potential impact of geothermal waters from the geothermal field in the uplands of Valencia on the alluvial plain underlain by the Dumaguete aquifer. Another historical area of interest for researchers was the Dumaguete dumpsite that operated in barangay Candau-ay from 1965 to 2021.

In 1994, the first significant groundwater study was reported by Geotecnica Corp., which conducted a hydrogeologic study of the Southern Negros Geothermal Field (SNGF), located on the uplands west of Dumaguete, and its geochemical and hydrogeologic impacts on the two major streams in the area (Okoy and Banica rivers) as well as the groundwater in the alluvial plain east and northeast of the SNGF.

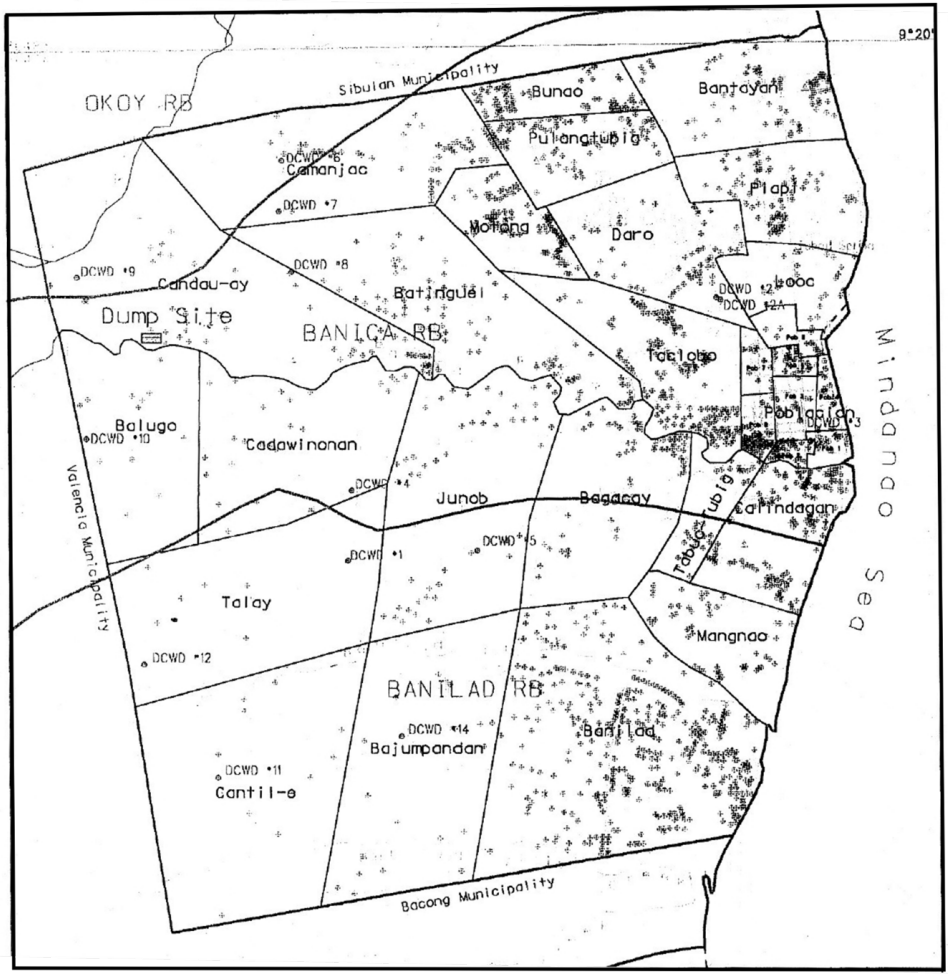
SWECO (a Swedish engineering consulting firm) completed a subsequent groundwater study in collaboration with the Philippine Local Water Utilities Administration (LWUA) 2001. The report by SWECO-LWUA (2001) was submitted to the LWUA and the Dumaguete City Water District (DCWD). Such a report included a collection of available data on

shallow and deep wells within the three river basins comprising the Dumaguete aquifer. It remains the most comprehensive hydrogeological study, which involved groundwater modeling of the aquifer. The SWECO study involved a compilation of data from around 16 public supply (deep production) wells, 1,736 public and private wells, and nine springs. SWECO completed the aquifer's first numerical groundwater modeling and simulation (using MODFLOW). Water supply scenarios for the next 30 years were presented. Despite such monumental compilation work, technical data from wells, such as construction details and water levels, are sparse. Only 25 wells had lithologic logs. Water-level histories were found from only 19 wells. Old chemical data (mostly 1980s and 1990s) on groundwater quality was available from only 67 wells. Analyses for most samples were for chloride, iron, manganese, hardness, and alkalinity. However, such technical data may not be reliable since it is missing QA/QC information, including detection limits and methodologies.

The last significant work was presented in a report by Caranto et al. (2006). They conducted elemental and isotope geochemistry to determine the relationship between the deep geothermal and shallow groundwater systems. The study involved 45 sources (shallow and deep wells, hot springs, cold springs, river water) sampled for various parameters from 1999-2002. Parameters included salinity, conductivity, temperature, oxygen-18 isotope, deuterium, tritium, CFC-11, CFC-12, CFC-113, and cations and anions (Cl, Br, Na, K, Li, and SO4). The relative ages of groundwaters in the Dumaguete aquifer were also determined using chlorofluorocarbon (CFC) data. Sampled water sources for CFC age dating included DCWD deep production wells (50-15 m) and other shallow wells (<50 m). For the age dating, five DCWD wells, six SNGF geothermal wells, and a creek were sampled. They also conducted numerical modeling of the groundwater system. Their model boundaries included only the Okoy and Banica river basins.

Figure 2

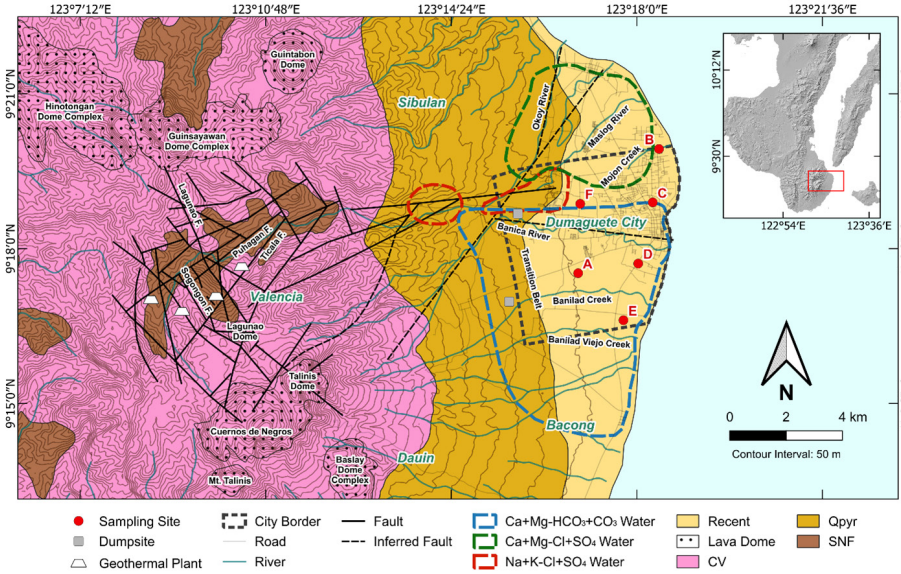
Public and Private Wells Inventoried by SWECO-LWUA (2001)



Note: "DCWD" wells were existing production wells as of 2001

Figure 3

Geologic Map of the SNGF-Dumaguete Area [modified after Antonio et al. (1976), Rae et al. (2004), Caranto (2005), Olivar & Apuada (2005), Caranto et al. (2006), Quinamot et al. (2015), and Ramirez (2016)]



Note: Red dots indicate sampling sites in Dumaguete City. Blue, green, and red dashed polygons indicate the areal extent of groundwater types from Caranto (2005). CV= Cuernos Volcanic Formation (Quaternary), Qpyr= Pyroclastic Deposits (Pliocene-Quaternary), SNF= Southern Negros Formation (Late Pliocene-Early Pleistocene). Base map data sources: NAMRIA, PhilGIS. Topographic contour interval 50 m.

Scope of Study

The Metro Dumaguete Water (MDW, formerly DCWD) regularly monitors the groundwater quality at their 16 pumping stations; however, analytical parameters only include total coliform, fecal coliform, and heterotrophic plate count (Emmanuel, 2017). Analytical results for additional parameters, if any, have not been published.

The investigation for this study involved sampling six randomly selected water sources: three domestic wells, one community well, one agricultural well, and one natural spring. The locations were spread out over the municipality's total area, at an average distance of 2.58 km apart. The land surface elevations at the six sites ranged from 5 to 43 m above Mean Sea Level (MSL). The estimated sampling depths at four wells ranged from 18 to 24 m below grade, while a fifth well was the deepest at 30 m. The spring in Banilad was, of course, at ground level.

Sampling was primarily performed in October and November of

2023. Analytical parameters included "analyze immediately" parameters (pH, temperature, dissolved oxygen or DO) as well as electrical conductivity (EC), total dissolved solids (TDS), and salinity using portable field instruments. A supplemental field survey was conducted from March 19 through 23, 2024. Random domestic wells and springs located mostly within the city's eastern half were sampled. A total of 20 wells and two springs were surveyed for field parameters: salinity, TDS, and EC.

Sample aliquots were sent to the laboratory for arsenic, cadmium, lead, mercury, chloride, nitrate, sulfate, phosphate, and ammonium analyses. The MDW lab and the Silliman University Chemistry Department performed the analyses. On March 9, 2024, supplementary sampling for bacteriological analysis was conducted. Lab analysis was performed in collaboration with biology students of Silliman University. The field readings and lab analytical results were evaluated using various statistical methods, presented in this report's Methodology, Results, and Discussion sections. A geostatistical evaluation consisted of Kriging and generating concentration isopleth maps for individual parameters.

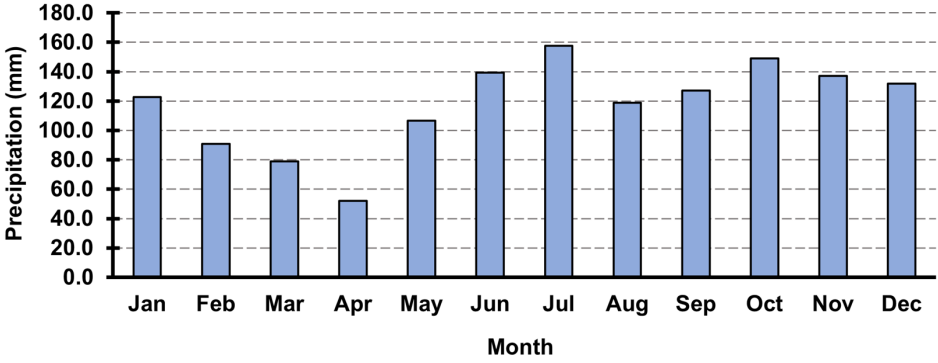
Physiography, Hydrology, and Hydrogeology of Dumaguete

Climate, Topography, and Soils

The Philippine archipelago has a tropical climate with relatively high temperatures, high humidity, and abundant rainfall. Only wet and dry seasons are experienced. Negros Island is classified as Type III in the Coronas Climate Classification used in the Philippines. As Type III, the area has one to three months of dry season from January to March with no pronounced maximum rain period from April through December (Caber & Rivera, 2023, PAGASA). Climate data from PAGASA (Dumaguete station) indicates that from 2004 to 2023, Dumaguete City had an average monthly air temperature of 28.1°C with an average minimum of 23.1°C and maximum of 33.0°C. The average annual precipitation was 1,412.2 mm. This is less than the average annual precipitation in the uplands (SNGF area) of 2,500 mm/yr. From 1991 to 2020, the average relative humidity was 81% annually, with the lowest percentage (79%) occurring in April and May and the highest percentage (84%) recorded in January.

Table 4

Average Monthly Precipitation at the Dumaguete Synoptic Station (2004-2023).



Source: PAGASA.

From the coastline, the land surface in Dumaguete slopes upward to the west and the neighboring town of Valencia (at 100 m above MSL), beyond which the elevations continue to rise towards the towering Cuernos de Negros, an inactive volcano (officially considered "potentially active" by PHIVOLCS). Viewing its topographic profile from afar, one can see that the city lies at the foot of the eastern concave slope of the volcano, which has a peak elevation of 1,900 m. The average gradient along the Dumaguete-Valencia Road is a steep 1.7%, while the gradient along the mainstem of the Banica River is slightly less at 1.5%.

Based on national soil classification nomenclature, Dumaguete is mantled by soils of the San Manuel-Taal Complex, San Manuel fine sandy loam, Dauin sandy loam, and Isabela clay. The following is a summary of soil distribution and descriptions from the report of Emmanuel (2017):

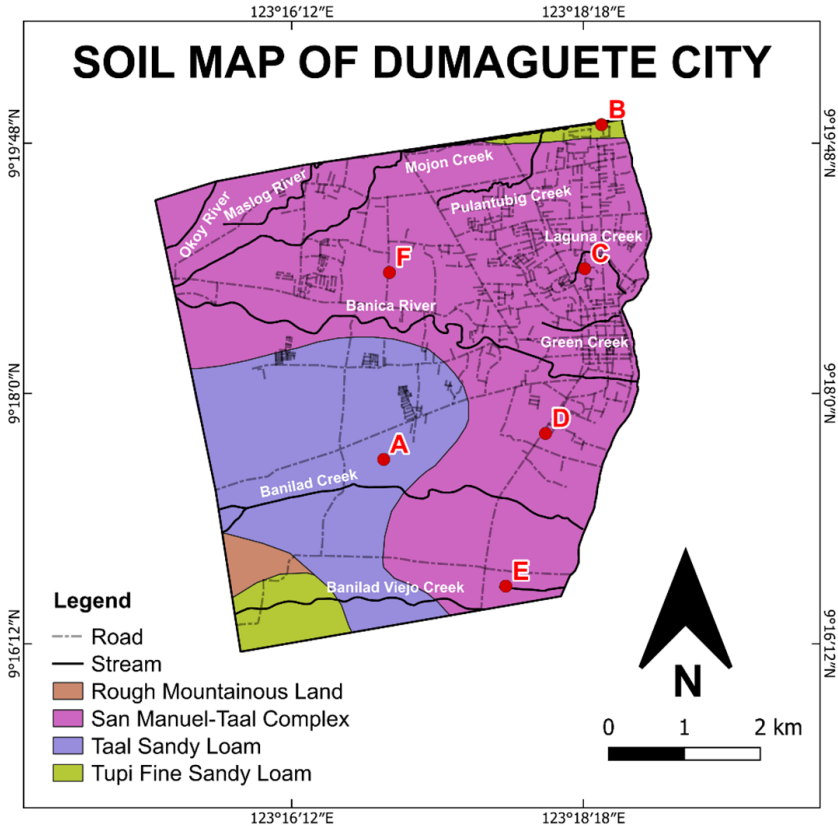
- San Manuel-Taal Complex: characterized by the San Manuel fine sandy loam and Taal sandy loam soils close to one another. It is distributed to the northwest of the city, is mostly sandy with large boulders on the surface, and with good drainage. This soil has been utilized for the cultivation of coconut trees and vegetables.
- San Manuel fine sandy loam: a kind of alluvium along the paths of rivers and creeks.
- Isabela clay: described as black, coarse, powdery, and loose. It tends to be sticky and plastic when wet. Its distribution is in barangays Looc, Piapi, and Bantayan.
- Dauin sandy loam: distributed to the east of the city, along the

coastline, with poor drainage and a shallow water table.

- Tupi fine sandy loam: distributed in a small area to the southwest of Dumaguete City

Figure 5

Map of the Soil Types in Dumaguete City [modified after Carmona & Ella (2022) according to the Bureau of Soils and Water Management]



Note: Sampling sites are shown as red dots. Soil definitions according to the Provincial Government of Negros Oriental (2011): San Manuel-Taal Complex is primarily sandy with good drainage and Taal soil found in the interior part of it; Taal Sandy Loam is water-laid volcanic soil around the eastern slope of Cuernos de Negros and is colored light gray to gray; Tupi Fine Sandy Loam is black, very friable and loose, with a fine granular structure to almost no structure, and the drainage is good. Other Data: Emmanuel (2017), Dumaguete City Engineering Office, NAMRIA, and PhilGIS.

Hydrology and Hydrogeology

Dumaguete falls within the Okoy, Banica, and Banilad watersheds (SWECO/LWUA, 2001). As a losing stream, the Okoy River contributes to the groundwater in the Dumaguete aquifer as it flows northeastward

through the barangays of Candau-ay and Camanjac, then veers northward, continuing through the town of Sibulan (SWECO/LWUA, 2001) and discharging into the Tañon Strait. The Banica River is also a losing stream and runs eastward through the middle part of the city, including the barangays of Balugo, Cadawinonan, Junob, and Tinago, where it finally drains into the Bohol Sea (SWECO/LWUA, 2001).

Based on pre-2001 data, the mean annual rainfall in the Okoy watershed was estimated at 2,428 mm/yr, while that of Banica watershed was 2,147 mm/yr. The Okoy watershed has a direct runoff of 948 mm/yr, while the Banica watershed has a direct runoff of 664 mm/yr. Evapotranspiration is estimated at 1166 mm/yr for the Okoy watershed and 1161 mm/year for the Banica watershed. Net recharge for the two watersheds was estimated to be 314 mm/yr and 322 mm/yr, respectively (SWECO-LWUA, 2001).

The Banilad Creek, Banilad Viejo Creek, and Mojon Creek are smaller streams that also play a role in the hydrogeology of the Dumaguete aquifer. It is likely that they are predominantly losing streams but were noted to be gaining streams toward the east, near the coastline where springs are common. The tributaries of the Mojon Creek have not been accurately mapped. Mojon flows eastward through rapidly urbanized areas of barangays Camanjac, Pulantubig, Buñao, and Bantayan, where it discharges into the Bohol Sea (also known as Mindanao Sea). Likewise, the two Banilad creeks, located in the city's southern section, also flow eastward, through an increasingly urbanized area, toward the Bohol Sea.

Dumaguete is underlain by andesitic to dacitic volcaniclastics of the Quaternary age, which includes tuffaceous sandstone, shale, and conglomerate interbeds (SWECO/LWUA, 2001). The porous materials of the aquifer are characterized by permeable volcaniclastic layers from the surface down to 150 m (SWECO/LWUA, 2001). Such layers consist of unconsolidated to semi-consolidated sandy clays, sands, cobbles, and boulders, mainly from reworked volcanic pyroclastics and weathered flows. A limestone lens within the upper 25 m of the stratigraphic column and located approximately one kilometer from the coast was reported by Caranto et al. (2006); however, its extent and stratigraphy have not been defined. The limestone is reportedly coralline and occurs within the Quaternary alluvium.

No borehole stratigraphy, sedimentology, correlation to outcrops, and stratigraphic nomenclature have been established for the aquifer. For this study, the more than 150 m of sedimentary sequence likely correlates to the Pleistocene and Holocene formations– the Southern Negros Formation and the Cuernos Volcanic Formation. The limited limestone unit within

the thick sequence of clastics may represent a brief marine transgressive event within predominantly alluvial fan and braided river environments. The "basement" rocks or the lower confining layer of the aquifer is unknown and has not been encountered in any deep well within the aquifer.

Figure 6

The Hydrogeologic Cross-section of the Dumaguete City Area [modified after Caranto et al. (2006)]

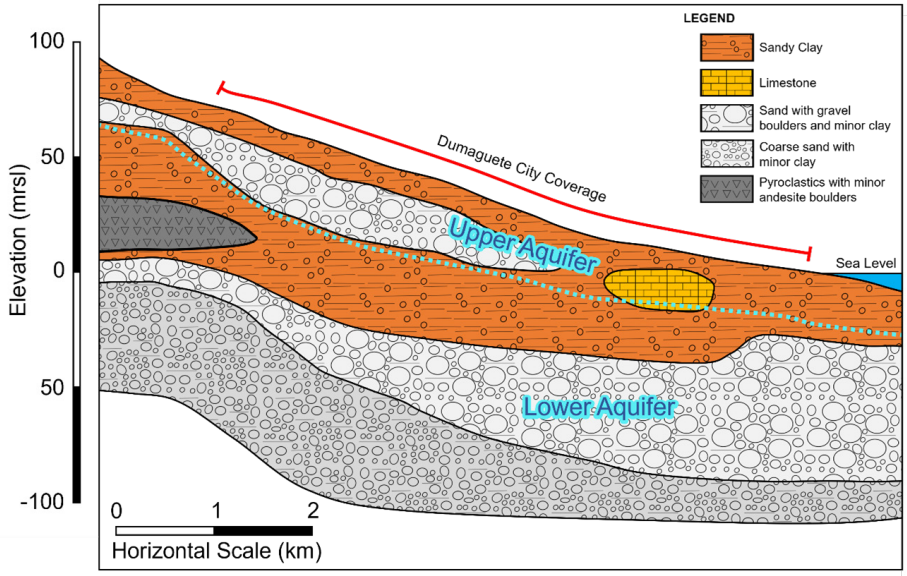
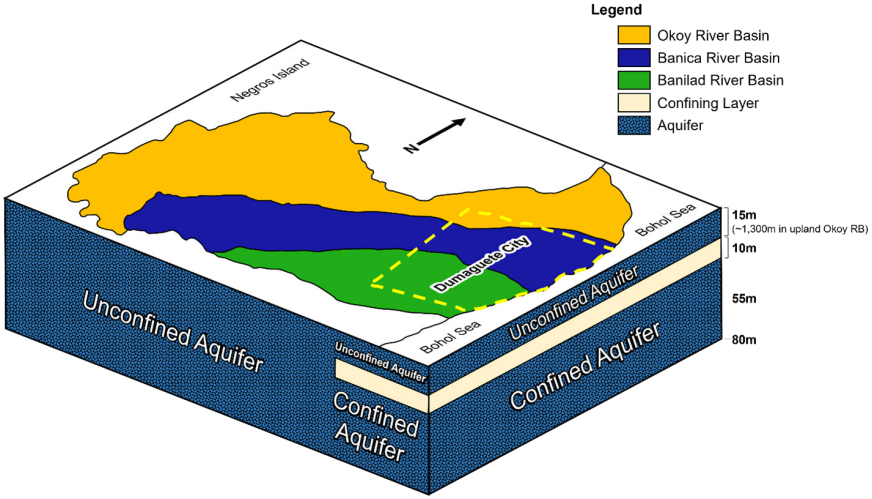


Figure 7

Block Diagram Suggesting of Groundwater Model of the Dumaguete Aquifer in the SGNF-Dumaguete Area [modified after SWECO/LWUA (2001)]



Note: Yellow dashed lines indicate the extent of Dumaguete City.

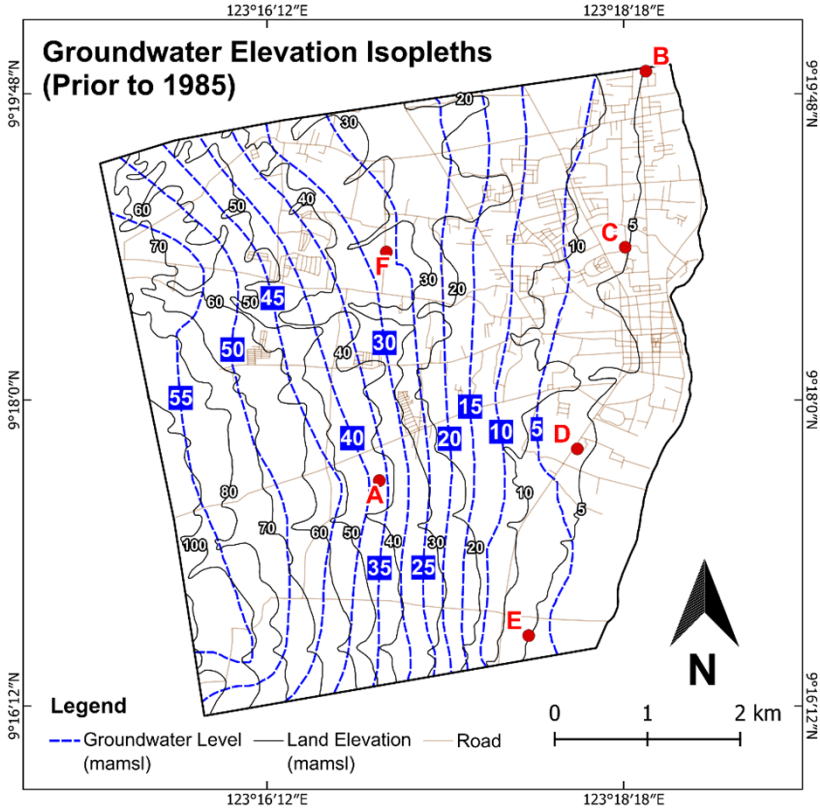
Groundwater in the aquifer originates from several sources. Vertical influx is from infiltration through precipitation and the losing streams of the Banica, Okoy, and Banilad rivers. There is also groundwater flux along the western municipal boundary due to lateral inflow from the upgradient and watershed areas of the Okoy and Banica rivers. Such lateral inflow has not been studied. Additionally, geothermal waters in higher elevations find their way into the groundwater via infiltration of hot spring waters (Caranto, 2005), although such contribution has not been quantified.

Groundwater flow is generally eastward and perpendicular to the coast (Geotecnica, 1994; Caranto, 2005). This is obvious when examining the land surface contours on a topographic map. Caranto (2005) noted that the water table occurred about 70 m below grade in the Palinpinon (Valencia) area. This is much lower than earlier reports of a high water table or potentiometric surface, including artesian conditions in this area in the 1970s (Geotecnica, 1994). Due to the recent installation of public water supply wells in the past several years, including the latest PS-21 well completed by MDW in March 2024, water levels are now presumed to be lower than 2005 levels. Cones of depression are likely developing around the actively pumping wells.

SWECO/LWUA (2001) noted that the elevation of the water table was zero near the coast, rising to 55 m above MSL at the contact between the plains and foothills ("transition belt" of reworked pyroclastic deposits located about 5 km from the coastline). Pre-1985 groundwater contours (from SWECO-LWUA, 2001) superimposed on land surface contours show shallow to above-ground water (artesian) levels in the southeast section of the city (Figure 8). Fieldwork during this study confirmed that specific locations along the city's eastern part have a water table higher than the stream stage, resulting in springs and gaining stream conditions.

Figure 8

Groundwater Elevation Isopleth Map of Dumaguete City before 1985 [modified after SWECO/LWUA (2001)]



Note: Sampling sites are shown as red dots—additional data from NAMRIA and PhilGIS.
Intercalations of less permeable clayey layers, particularly along the coast, have reportedly resulted in local artesian conditions. Such a laterally limited confining layer with an underlying "artesian aquifer" of a limited extent was modeled by SWECO/LWUA (2001) in their groundwater model and simulation (Figure 7). Fieldwork for this study, however, did not find flowing artesian wells but rather only surficial springs, which are a result of either seepage faces or subsurface fractures and faults that act as pathways for upward-flowing artesian groundwater from the deeper, confined part of the aquifer.

The hydrogeologic cross-section of Caranto et al. (2006) depicts an "upper" and a "lower" aquifer (Figure 6); however, there is no detailed description of the two apparent aquifers, the confining layer, and water levels. Instead, Caranto (2006) reports that the uniformity of chemical and isotope characteristics of the groundwater indicates a single unconfined aquifer with occasional lenses of clay. At this point, the model by SWECO/LWUA of a confining clay layer (between a lower confined aquifer and an upper water table aquifer) at a depth of 15 m, with a thickness of 10 m, and a limited lateral extent (one km wide) along the eastern part of the city

(Figure 7) seems more plausible. Additional hydrogeologic investigation is warranted.

The total annual groundwater potential as of 2001 was estimated to be 50,615 cubic meters per day (cum/d) and includes 18,682 cum/d from direct recharge and 31,933 cum/d from lateral inflow from the upland areas of the Banica River basin. In 2001, the total withdrawal from the aquifer was 21,826 cum/d. The predicted withdrawal rate in 2030 was estimated at 40,167 cum/d (SWECO/LWUA, 2001).

The Okoy and Banica rivers are major contributors to the "shallower groundwaters" in the aquifer (Caranto, 2005). At the "transition belt" of reworked pyroclastic deposits, the groundwater levels range from 40 to 60 m below the river bottoms. However, the groundwater levels on the plains are only a few meters below the river bottoms. River water seepage into the surrounding permeable sediments makes the Okoy and Banica rivers highly influential near the porous transition belt (SWECO/LWUA, 2001) and towards the plains. Both rivers can be classified as losing streams along much of their mainstems; thus, contaminants would find their way into the groundwater. A similar condition presumably occurs in the Banilad River basin.

Toward the coastline, where the water table is shallow, Okoy, Banica, and the two Banilad rivers appear to be gaining streams. The exact points along the rivers where the streams become gaining or losing have not been studied.

Significant Findings of Previous Works

Groundwater Investigations

The Dumaguete aquifer is influenced by the outflowing geothermal waters from the SNGF via groundwater recharge from surficial hot springs (Caranto, 2005). The resulting mixture of the geothermal and meteoric waters in the aquifer has resulted in three chemical groundwater types, namely Na+K-Cl+SO_4 waters (hot spring origin), Ca+Mg-HCO_3+CO_3 waters ("typical" meteoric) and Ca+Mg-Cl+SO_4 waters (typical waters mixed with hot spring waters) as shown on the map in Figure 3 (modified from Caranto, 2005). In and around the barangays of Junob and Cadawinonan, "deep" groundwater is described as typical (meteoric water), while deep groundwater under the Batinguel and Candau-ay area is relatively chloride-rich and influenced by both Okoy and Banica rivers (Caranto, 2005). It is noted, however, that there is no clear definition of "deep" and "shallow"

groundwater. Northeast of the geothermal plant (i.e., within the Okoy River basin), the groundwater is characterized as "typical" (meteoric) water mixed with hot spring waters based on isotopic and elemental chemistry (Caranto, 2005).

According to SWECO/LWUA (2001), six wells sampled in the Okoy and Banica river basins and one near Banica River yielded relatively high chloride contents ranging from 110 to 303 mg/L. The chloride source was considered "unknown" since the wells were located too far inland (SWECO/LWUA, 2001) away from the coast and seawater. Later work by Caranto (2005) suggested that geothermal waters are a source of chloride. The SWECO/LWUA (2001) report also presented available annual sampling results from 67 wells between 1983 and 1994; up to 10 wells had various iron, manganese, mercury, and arsenic detections, some exceeding "permissible limits." However, there was no additional discussion of the results and "permissible limits."

The "shallow" and "deep" aquifers (upper and lower parts of the single aquifer?) are recharged mainly during the rainy season, with little to no recharge during the dry season, according to isotopic data. Historical pumping tests by the DCWD indicated higher hydraulic conductivities in shallow wells and slightly lower hydraulic conductivities in deeper wells (Caranto, 2005). This would be expected from increasing compaction and lithification of the sediments with depth. The average hydraulic conductivity values obtained from pumping the shallow and deep wells were 0.00025 and 0.00005 m/s, respectively. Transmissivity values ranged from 1.91 to 0.0301 m2/s for the deeper wells (Caranto, 2005).

Impact of Dumpsite

The city dumpsite was established in 1965, with an area of 2.3 hectares in barangay Candau-ay, about five kilometers from downtown. The dumpsite had not been adequately designed, and there were no essential components such as a liner, daily cover, flood control, odor control, landfill gas collection system, leachate collections system, or groundwater monitoring system. By 2010, accumulated waste piles were estimated at 84,000 m3, with unsegregated waste from households and commercial and industrial establishments (Emmanuel, 2017).

The dumpsite was situated along the Banica River and about a few hundred meters from housing projects. Water flooding into the dumpsite was reported to occur during heavy rainfall, which raised concerns about

groundwater contamination. The water table was about 5 to 12 m below the surface, separated from contact with the waste materials by the moderately to highly permeable San Manuel-Taal Complex, making possible the leaching of contaminants into groundwater. Hydrogen sulfide and ammonia were contributors to the foul smell; methane and carbon dioxide were among the notable greenhouse gases emitted in the place (Emmanuel, 2017). Chemical and biological testing of leachate (discharging from the side of the mound and into the Banica River) 2010 revealed a high BOD of 5,128 mg/L. Total suspended solids (TSS) were also at 846.7 mg/L and nitrate at 1.06 mg/L. BOD was also measured from the Banica River water upstream and downstream of the dumpsite area, and higher concentrations were revealed downstream by more than double, from 0.69 mg/L upstream to 1.51 mg/L downstream (Emmanuel, 2017).

In 2010, soil samples collected from the dumpsite had a maximum lead content of 72.9 mg/kg and cadmium at 58.9 mg/kg. The acceptable level of lead was <80 mg/kg and cadmium was <1.7 mg/kg (Emmanuel, 2017). Thus, cadmium significantly exceeded the acceptable limit, while lead was close to its corresponding acceptable limit.

It was postulated that groundwater underneath the dumpsite is contaminated by leachate, with likely high BOD, coliform, inorganic pollutants, heavy metals, and other organic contaminants (Emmanuel, 2017). The city's current water purveyor, MDW, has four pumping stations near the dumpsite, which could be impacted by potential contamination. Three of these (Pumping Stations 9, 10, and 18) are upgradient of the facility, while Pumping Station 8 is 1,000 m downgradient and more vulnerable to contamination by any leachate (SWECO/LWUA, 2001; Emmanuel, 2017).

In the past several years, there have been continuing indications of leachate outflowing directly into the Banica River (Emmanuel, 2017). Recent work by Romo (2024) confirms that leachate seeps out of the dumpsite mound and into the Banica River. Since the Banica is a losing stream, contaminants are likely impacting the groundwater.

S.U. biology student F. Romo conducted the last known groundwater investigation of the dumpsite as part of her senior thesis (Romo, 2024). Romo sampled the leachate from the mound and seven water supply wells closest to the dump site. Her samples were analyzed for bacteria, pH, electrical conductivity, DO, biochemical oxygen demand (BOD), ammonium, phosphate, sulfate, cadmium, and lead. Romo (personal communication, March 2024) indicated that phosphate (at four sites) and ammonium (at three sites) were detected at concentrations exceeding the Department of Environment and Natural Resources (DENR) standards. In reviewing her

results, it was noted that DO levels were all out of compliance, below the minimum 5 mg/L, which was the DENR's criterion for Class AA waters. Similarly, BOD levels at four sites exceeded the 1.0 mg/L DENR criterion for Class AA waters. Such exceedances suggest that a leachate plume has developed and contaminated the aquifer.

Besides the MDW, over a thousand households, communities, and establishments independently extract groundwater from wells. These are also vulnerable to groundwater contamination from the leachate (Emmanuel, 2017).

Methodology

Sampling Sites

For this study, five water supply wells and one spring (a total of 6 sites in 6 barangays) were chosen for random sampling of groundwater in late 2023. (See Figure 9 for photos and Figures 1, 3, 5, and 8 for maps of the sampling sites.) Site A in Junob has an abandoned domestic well temporarily used by construction workers. (The contractor and site owner have requested anonymity.) Two of the wells are owned by Silliman University (S.U.), with one used for agricultural water supply located in Silliman Farm in Bantayan (Site B) and the other (Site C) serving as a community well for several dormitories and other buildings within the university campus (such area being part of Daro). Site D has a domestic well in Calindagan. Site E is a natural spring used by the local community in Banilad. Site F has a domestic well in a predominantly residential area along Boni Catarata Street in Batinguel. At around the same time but under a separate study, S.U. biology student F. Romo sampled this 60 ft well. Her sample was designated "GW-6" and analyzed for similar parameters, except for arsenic, mercury, nitrate, and chloride, which were all analyzed for this study. Table 1 below summarizes the information on the sampling sites.

Table 1

Information on Sampling Sites and Groundwater Sources Sampled and Their Assigned Labels

Sampling Site	A	B	C	D	E	F
Location (Barangay)	Junob, Dumaguete City	Bantayan, Dumaguete City	Daro, Dumaguete City	Calindagan, Dumaguete City	Banilad, Dumaguete City	Batinguel, Dumaguete City
Address	Jose Romero Road	Hibbard Avenue	Aldecoa Drive	Lamberto Macias Road	Santa Monica Road	Boni Catarata Street
Source Type	Well	Well	Well	Well	Spring	Well
Latitude	9°17'31.52"	9°19'55.99"	9°18'53.86"	9°17'42.72"	9°16'36.83"	9°18'52.18"
Longitude	123°16'51.69"	123°18'25.84"	123°18'18.55"	123°18'1.63"	123°17'44.46"	123°16'54.17"
Elevation	43 MAMSL	5 MAMSL	5 MAMSL	6 MAMSL	5 MAMSL	33 MAMSL
Depth (est.)	18.2 m	24.3 m	30.4 m	18.2 m	N/A	18.2 m
Pump Type	Hand Pump	Centrifugal Pump	Submersible Pump	Hand Pump	Free flowing	Hand Pump
Average Discharge	0.117 L/s	0.252 L/s	1.287 L/s	0.078 L/s	0.266 L/s	0.057 L/s
Usage	Former domestic	Agricultural	Community	Domestic	Community	Domestic
Year Installed (circa)	1993	1950	2001	1970	N/A	1970
Owner	N/A (Abandoned)	Silliman University	Silliman University	Mrs. Enriqueta Aranas	Mrs. Georgina Villahermosa	Mrs. Rustica Baylon
Remarks	Construction site. Well, to be decommissioned.	Approximately 10 m from Mojon Creek and a natural spring	Approximately 90 m from Laguna Creek. Supplies water to dorms and buildings	The owner previously reported bacterial contamination.	Enclosed in concrete tank with metal and PVC pipes as outlets.	Pumped dry at 20 and 40 ft. Completed at 60 ft.

MAMSL= meters above mean sea level. N/A= not applicable.

Figure 9

Photos of the Groundwater Sources Sampled: (A) Junob, (B) Bantayan, (C) Daro, (D) Calindagan, (E) Banilad, and (F) Batinguel.

Analytical Parameters

The water samples from each site were analyzed for field parameters: temperature, salinity, TDS, pH, EC, and DO, and for lab analytes: arsenic, cadmium, lead, mercury, chloride, nitrate, sulfate, phosphate, and ammonium. Bacteria, such as total coliform and fecal coliform, were later added to the scope of work. All parameters except for cadmium, lead, ammonium, phosphate, and sulfate were analyzed for Site F. Data for the exceptions was instead obtained from the work of biology student F. Romo, who sampled the same well (but named it "GW-6") for similar parameters around the same time.

Preparation of Field Instruments

All necessary calibrations of the field instruments followed the manufacturer's protocols before fieldwork. The Extech ExStik EC500 conductivity and pH sensors were calibrated first, followed by the Extech ExStik DO600. Procedures outlined in the manufacturer manuals were closely followed. The EC500's electrode was calibrated by submerging it into

three standardizing solutions (84, 1413, and 12,880 µS/cm). The pH electrode was calibrated using a 3-point method by separately immersing it in pH 7, pH 4, and pH 10 buffer solutions to ensure accuracy. Calibration of the DO600 was calibrated each day of field use by turning it on and leaving it idle while displaying the % measurement unit for three minutes until it fully polarized.

Preparations at the Sampling Site

Under USEPA protocols, the water supply wells were pumped for at least 15 minutes to evacuate stagnant water and purge the volume of water in the well casing and intake pipe to ensure the collection of fresh samples that represent actual groundwater conditions. The natural spring in barangay Banilad was directly sampled since water continuously flows from the discharge pipe of a concrete enclosure.

Analyzing Field Parameters

The EC500 and DO600 were used at each site to analyze field parameters, including the "analyze immediately" parameters: pH, temperature, and DO. Other field parameters included salinity, TDS, and EC. A plastic sample cup pre-rinsed with distilled water was conditioned five times using well water before filling it to a volume of 20 ml for submerging the instruments' electrodes. For DO readings using the DO600, the electrode was continuously and gently stirred in the sample cup until a stable reading was achieved and recorded. Three trials were performed at each sample location. Following each trial, the electrode was rinsed with distilled water and then patted dry with dedicated tissue in preparation for the subsequent trial measurement.

Similarly, the EC500 was prepared by rinsing the electrode with distilled water. The electrode was then patted dry using tissue, submerged into the sample cup, and briefly stirred to remove air bubbles. Readings were then noted in the following sequence: temperature in °C, pH in standard pH units, salinity in ppm, TDS in ppm, TDS in mg/L, and EC in µS/cm. Afterward, the electrode was rinsed again with distilled water, patted dry with tissue, and set aside on a fresh, clean piece for the subsequent trial.

Sampling for Lab Analysis

After purging the well at each site, sample aliquots were collected in

a 1-liter sterilized plastic sample bottle provided by Metro Dumaguete Water (MDW) Laboratory and in a 500 mL plastic distilled water bottle for the S.U. Chemistry lab. The sample jars were conditioned or rinsed five times with well water before collecting a final sample. The jars were then labeled and stored in a cooler with ice packs for preservation during transport. While rinsing the 1-liter jar, the well's pumping rate was also determined by noting the time needed to fill up the jar. This involved three trials, which were averaged. Immediately following sample collection, the samples were submitted to the two labs. The 1-liter jars were submitted to MDW Laboratory, while the 500 mL jars were submitted to Dr. M. Cerdania of the S.U. Chemistry Department.

Lab Analytical Methodologies

The MDW Laboratory performed the analysis of arsenic, cadmium, and lead using electrothermal atomic absorption spectrometry (AAS); mercury using hydride generation-AAS; nitrate via UV spectrophotometric screening; chloride via argentometry; sulfate via nephelometry; and phosphate via the ascorbic acid molybdo-tartrate ascorbic acid method. M. Cerdania of the S.U. performed an analysis for ammonium. Chemistry Department using the Salicylate Hypochlorite method.

Table 2 below summarizes the analytical methodologies for this study. Only field parameters and arsenic, mercury, nitrate, and chloride were analyzed for Site F. The other analytical data for Site F were obtained from the study by Romo (2024), who sampled the same well (designated Site F for this study, but "GW-6" for her study) during the same period.

Table 2

Analytical Methods, Venues, and Analysis

PARAMETER	ANALYTICAL METHOD	LOCATION	ANALYST(S)
Temp.	ExStik EC500 Digital thermometer	In-Situ	Researcher
pH	ExStik EC500 (Proprietary)	In-Situ	Researcher
EC	ExStik EC500 (Proprietary)	In-Situ	Researcher
TDS	ExStik EC500 (Proprietary)	In-Situ	Researcher
Salinity	ExStik EC500 (Proprietary)	In-Situ	Researcher

DO	ExStik DO600 (Proprietary)	In-Situ	Researcher
As	Electrothermal-AAS	MDW Laboratory	MDW Laboratory
Cd	Electrothermal-AAS	MDW Laboratory	MDW Laboratory
Pb	Electrothermal-AAS	MDW Laboratory	MDW Laboratory
Hg	Hydride Generation-AAS	MDW Laboratory	MDW Laboratory
NO3-	UV Spectrophotometric Screening	MDW Laboratory	MDW Laboratory
Cl-	Argentometry	MDW Laboratory	MDW Laboratory
PO4-3	Ascorbic Acid Molybdo – Tartrate Ascorbic Acid Method	MDW Laboratory	MDW Laboratory
SO4-2	Nephelometry	MDW Laboratory	MDW Laboratory
NH4+	Salicylate Hypochlorite	S.U. Chemistry Laboratory	Dr. Melchor Cerdania
TC	Membrane Filtration and Incubation at 37 °C	S.U. Biology Laboratory	Dr. Robert Guino-o, biology students, and the researcher
FC	Membrane Filtration and Incubation at 44 °C	S.U. Biology Laboratory	Dr. Robert Guino-o, biology students, and the researcher

Temp.= temperature, EC= electrical conductivity, TDS= total dissolved solids, DO= dissolved oxygen, As= arsenic, Cd= cadmium, Pb= lead, Hg= mercury, NO_3^- = nitrate, Cl- = chloride, PO_4^{-3} = phosphate, SO_4^{-2} = sulfate, NH_4^+ = ammonium, TC= total coliform, FC= fecal coliform, AAS= atomic absorption spectrometry, UV= Ultraviolet, MDW= Metro Dumaguete Water, SU= Silliman University.

Results

The analytical results were compared to the Department of Health (DOH) Drinking water standards and the DENR water quality guidelines for Class A and AA water bodies. Additionally, international standards and criteria (for drinking water) of the World Health Organization (WHO) and the U.S. Environmental Protection Agency (USEPA) were used for the evaluation of specific results. The purpose of the multiple references was to compare the results to the most stringent standards and criteria. These are presented in Table 3 below. These standards (enforceable) and criteria or guidelines (non-enforceable) are hereafter variably referred to as "referenced thresholds," "referenced standards," "referenced criteria," or "referenced limits."

Table 3

Water Quality Standards from Multiple agencies, including the Department of Health (DOH), Department of Environment and Natural Resources (DENR), World Health Organization (WHO), and United States Environmental Protection Agency (USEPA)

PARAMETER	PNSDW (DOH, 2017)	WQG - Class A (DENR, 2016, 2021)	GDWQ (WHO, 2011, 2022)	NPDWR (USEPA, 2009)	Unit
Temp.	-	26–30	-	-	°C
pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	pH units
EC	-	-	1500	-	µS/cm
TDS	600	-	600	500	mg/L
Salinity	-	-	-	-	
DO	-	5 (minimum)	-	-	mg/L
As	0.01	0.01	0.01	0.01	mg/L
Cd	0.003	0.003	0.003	0.005	mg/L
Pb	0.01	0.01	0.01	0.015	mg/L
Hg	0.001	0.001	0.006	0.002	mg/L
NO_3-	50	7	50	10	mg/L
Cl^-	250	250	250	250	mg/L
PO_4^{-3}	-	0.025	-	-	mg/L
SO_4^{-2}	250	250	250	250	mg/L
NH_4^+	-	-	35	-	mg/L
TC	< 1	-	0	0	CFU/100 mL
	< 1.1	-	0	0	MPN/100 mL
FC	< 1	-	0	0	CFU/100 mL
	< 1.1	50	0	0	MPN/100 mL

Temp.= temperature, pH= potential of hydrogen, EC= electrical conductivity, TDS= total dissolved solids, DO= dissolved oxygen, As= arsenic, Cd= cadmium, Pb= lead, Hg= mercury, NO_3^- = nitrate, Cl- = chloride, PO_4^{-3} = phosphate, SO_4^{-2} = sulfate, NH_4^+ = ammonium, TC= total coliform, FC= fecal coliform, CFU= colony forming units, MPN= most probable number, N/A= not applicable, (-)= no information. PNSDW= Philippine National Standards for Drinking Water. WQG= Water Quality Guidelines. Class A= Water bodies intended as water supply sources requiring conventional treatment to meet the latest PNSDW. GDWQ= Guidelines for Drinking-Water Quality. NPDWR= National Primary Drinking Water Regulations.

The health risks associated with the pollutants addressed in this study are summarized in Table 4 below. The parameters of this study were based on their common occurrence in groundwater (from the review of literature), occurrence in geothermal fields, and detection in historical sampling of wells in the area. Other factors were considered when selecting

the parameters, namely, the analytical cost and budget constraints for the senior thesis study and the limitations in the analytical capabilities of the laboratories in Dumaguete. For example, the local laboratories are currently incapable of analyzing volatile organics, PAHs, pesticides, herbicides, and PCBs.

Table 4

Typical Problems Arise from Contaminants in Domestic Water Supplies (Litke, 1999; USEPA, 2009; Tchounwou et al., 2012; WHO, 2011, 2022; NJDOH)

PARAMETER	POTENTIAL HEALTH AND OTHER EFFECTS
pH	Corrosion of equipment
Total Dissolved Solids (TDS)	Unpalatable water, scaling in equipment
Arsenic (As)	Damage to skin and circulatory system, carcinogen, death
Cadmium (Cd)	Kidney damage, organ irritation, poisoning, death
Lead (Pb)	Neurological problems, kidney damage, high BP, carcinogen
Mercury (Hg)	Kidney damage, toxicity, allergic reactions, corrosion
Nitrate (NO_3^-)	Blue-baby syndrome, illness, shortness of breath, death
Chloride (Cl^-)	Salty taste, corrosion of equipment
Phosphate (PO_4^{-3})	Eutrophication (growth of algae)
Sulfate (SO_4^{-2})	Laxative, dehydration, corrosion
Ammonium (NH_4^+)	Chlorine reactions, respiratory problems, irritation or burns
Coliform Bacteria	Diarrhea, cramps, nausea, headaches, or other symptoms

Field Parameters

The line graphs in Figure 10 show the results for field parameters (pH, temperature, DO, salinity, EC, and TDS). Site B (Bantayan) had the highest values for these parameters, while Site E (Banilad) exhibited the lowest. Sites C and D approached the maximum contaminant level (MCL at 500 mg/L) for TDS as defined by the USEPA (2009). Site B exceeded the MCL set by the USEPA (2009) and the 600 mg/L limit set by the DOH

(2017) and the WHO (2011, 2022). Sites A (Junob) and F (Batinguel), situated at higher elevations toward the west, exhibited significantly lower readings of such parameters.

For temperature, it was noted that Site D (Calindagan) had the highest temperature reading (32.6 0C). The same site had the lowest DO reading at 3.32 mg/L. All sampling sites, except Site F, had non-compliant DO levels below the 5 mg/L DENR minimum limit or water quality guideline for Class A water bodies (DENR 2016, 2021). Site F had a DO of 5.13 mg/L, which barely passed the DENR limit. DO is typically inversely proportional to water quality; thus, a low DO level indicates polluted water.

The concentration isopleth maps for field parameters pH, EC, TDS, and salinity show a consistent trend of increasing concentrations toward the northeast, with the highest results found at Site B (Bantayan). These four parameters were highly correlated in the Pearson product-moment correlation matrix.

In comparing the results with regulatory standards and criteria, Site B was found to have TDS (at 703 mg/L) exceeding the 500 mg/L MCL of the USEPA (2009), the 600 mg/L limit of the DOH (2017), and the 600 mg/L limit of the WHO (2011, 2022). Sites C and D approached the USEPA limit of 500 mg/L (see graph, Figure 10).

Ions and Coliform Bacteria

Nitrate had elevated concentrations at four sites-- A, C, E, and F-- which exceeded DENR (2016, 2021) and USEPA (2009) limits. The concentration isopleth map for nitrate suggests an increasing trend from east (coastal areas) to west (uplands). Chloride concentrations were all below the referenced limit of 250 mg/L. In five samples, chloride was low and ranged from 14.4 to 46.9 mg/L, while the sample from Site D (Calindagan) had the highest chloride at 181 mg/L, which was determined as an outlier (based on the 1.5 IQR test) as shown on the box and whisker plot (Figure 14). Such chloride outlier suggests proximity to a contaminant source, such as a nearby leaky septic tank or the frequently ponded (with sewage water) area near the well. The possibility of saltwater influence is presented in the Discussion section of this report. This relatively high chloride level may explain the non-detect bacterial count (salty solution inhibiting bacterial growth) at Site D, as suggested by the negative correlation between chloride and bacteria in the Pearson product-moment correlation chart.

Phosphate at all sites exceeded the DENR (2016, 2021) limits, having concentrations ranging from 0.13 to 0.45 mg/L. Sites B and D (Bantayan and

Banilad, respectively) had the highest concentrations (0.42 to 0.45 mg/L),which may be attributable to the historical agricultural land use at Site B and a mixed residential and farming use of the land around Site D.

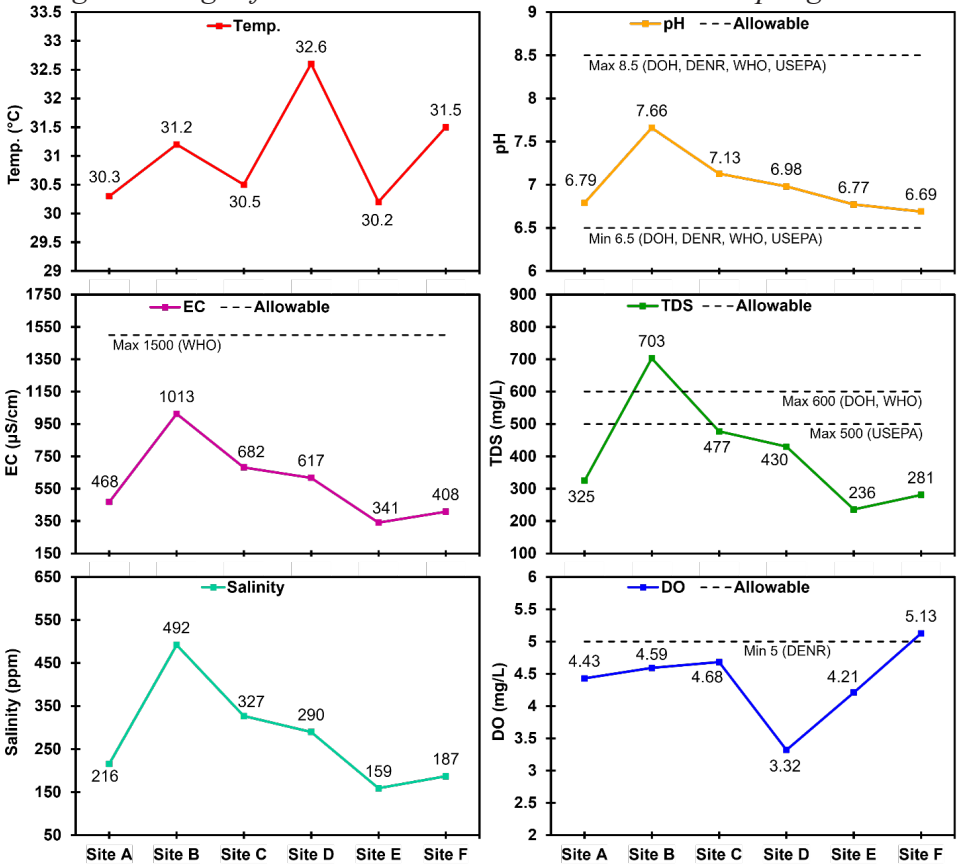
Total coliform (TC) bacteria at Sites A, C, and E exceeded the maximum threshold of <1 Colony-Forming Unit (CFU)/100 mL recommended by the DOH (2017). Site B had seemingly low (4 CFU/100 mL) but non-compliant TC levels. Sites D and F had no TC presence, although one of the three trials from the Site F sample resulted in trace amounts of fecal coliform (FC). TC was highly correlated with nitrate in the Pearson product-moment correlation matrix (Figure 13).

Heavy Metals

Lab analysis of heavy metals revealed generally compliant concentrations across all six sites. Arsenic concentrations were within the acceptable limit (0.01 mg/L) at all sites; however, Site C (Daro) had an elevated concentration of 0.009 mg/L, which is borderline. Cadmium and lead were not detected above their detection limits (0.001 mg/L and 0.003 mg/L, respectively) at any site except Site A (Junob), where a trace amount of cadmium (0.001 mg/L) was detected. Such cadmium level is compliant with water quality standards. Mercury was not detected across all sites, with a detection limit (0.001 mg/L) that coincides with the regulatory limit established by the DOH (2017) and DENR (2016, 2021).

Figure 10

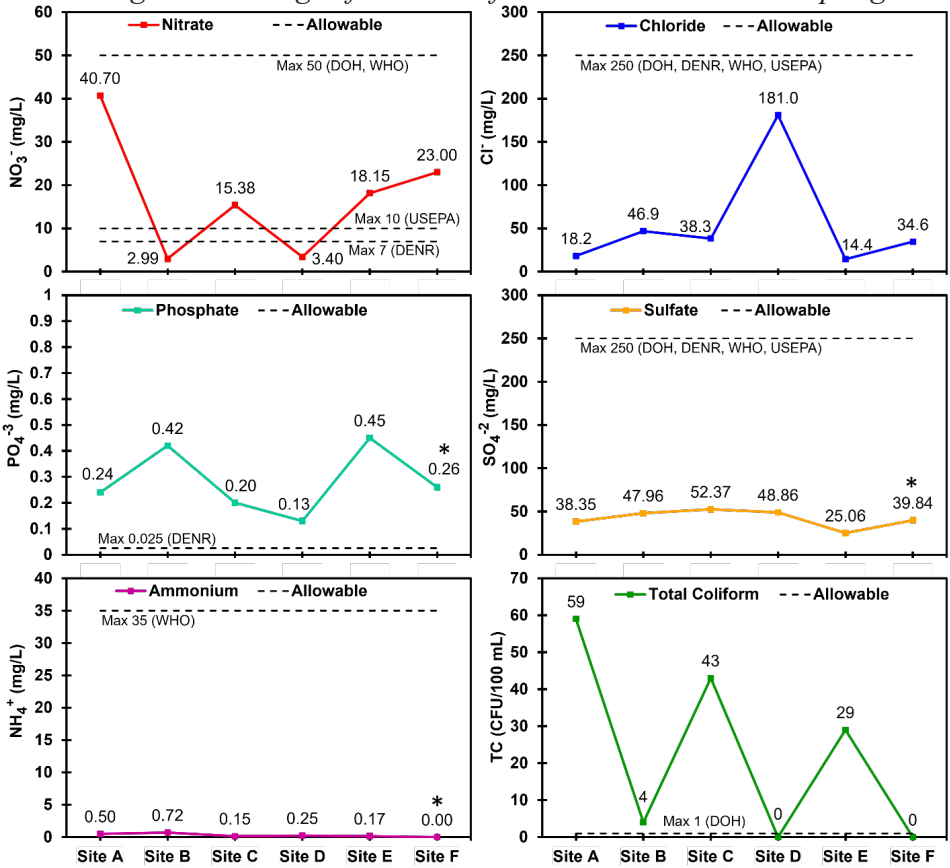
Average Readings of In-situ Field Parameters at Each Sampling Site.



Temp.= temperature, EC= electrical conductivity, TDS= total dissolved solids, DO= dissolved oxygen, Max= maximum, Min= minimum. For regulated parameters, the maximum/minimum allowable concentrations are indicated along with the authorities that established the standards (i.e., USEPA, 2009; DOH, 2017; DENR, 2016, 2021; and WHO, 2011, 2022).

Figure 11

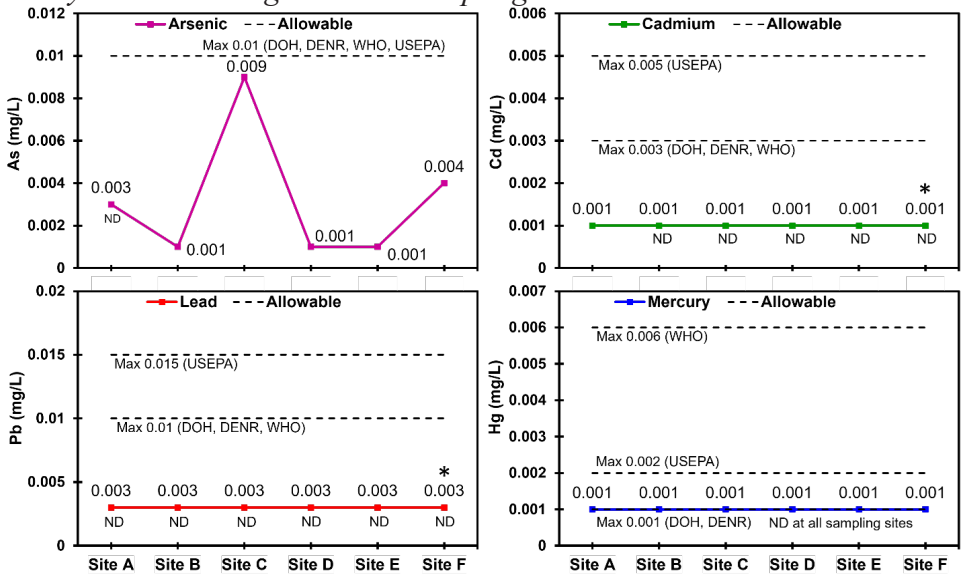
Ion Readings and Average of Total Coliform Results at Each Sampling Site.



NO_3^- = nitrate, Cl^- = chloride, PO_4^{-3} = phosphate, SO_4^{-2} = sulfate, NH_4^+ = ammonium, TC= total coliform, (*)= indicates data obtained from Romo (2024). The maximum allowable concentrations are indicated for regulated parameters, along with the authorities that established the standards (i.e., USEPA, 2009; DOH, 2017; DENR, 2016, 2021; and WHO, 2011, 2022).

Figure 12

Heavy Metal Readings at Each Sampling Site



As= arsenic, Cd= cadmium, Pb= lead, Hg= mercury, ND= non-detect, (*)= indicates data obtained from Romo (2024). The maximum allowable concentrations and the authorities established the standards (i.e., USEPA, 2009; DOH, 2017; DENR, 2016, 2021; and WHO, 2011, 2022) are indicated.

Figure 13

Pearson Product-moment Correlation Matrix of Parameters

	Temp.	pH	EC	TDS	Sal.	DO	As	NO_3^-	Cl^-	PO_4^{-3}	SO_4^{-2}	NH_4^+	TC	FC
Temp.		0.1	0.2	0.2	0.2	-0.5	-0.3	-0.6	0.9	-0.5	0.5	-0.1	-0.8	0.2
pH	0.1		1.0	1.0	1.0	0.0	-0.1	-0.6	0.1	0.3	0.6	0.7	-0.2	-0.4
EC	0.2	1.0		1.0	1.0	0.0	0.0	-0.6	0.2	0.1	0.7	0.7	-0.3	-0.4
TDS	0.2	1.0	1.0		1.0	0.0	0.0	-0.6	0.2	0.1	0.7	0.7	-0.3	-0.4
Sal.	0.2	1.0	1.0	1.0		0.0	0.0	-0.6	0.2	0.1	0.7	0.7	-0.3	-0.4
DO	-0.5	0.0	0.0	0.0	0.0		0.5	0.4	-0.6	0.3	-0.1	-0.1	0.1	0.6
As	-0.3	-0.1	0.0	0.0	0.0	0.5		0.2	-0.3	-0.4	0.4	-0.4	0.4	0.1
NO_3^-	-0.6	-0.6	-0.6	-0.6	-0.6	0.4	0.2		-0.6	-0.1	-0.4	-0.1	0.7	0.2
Cl^-	0.9	0.1	0.2	0.2	0.2	-0.6	-0.3	-0.6		-0.6	0.5	0.0	-0.5	-0.2
PO_4^{-3}	-0.5	0.3	0.1	0.1	0.1	0.3	-0.4	-0.1	-0.6		-0.6	0.3	-0.1	-0.1
SO_4^{-2}	0.5	0.6	0.7	0.7	0.7	-0.1	0.4	-0.4	0.5	-0.6		0.2	-0.2	-0.1
NH_4^+	-0.1	0.7	0.7	0.7	0.7	-0.1	-0.4	-0.1	0.0	0.3	0.2		0.1	-0.6
TC	-0.8	-0.2	-0.3	-0.3	-0.3	0.1	0.4	0.7	-0.5	-0.1	-0.2	0.1		-0.4
FC	0.2	-0.4	-0.4	-0.4	-0.4	0.6	0.1	0.2	-0.2	-0.1	-0.1	-0.6	-0.4	

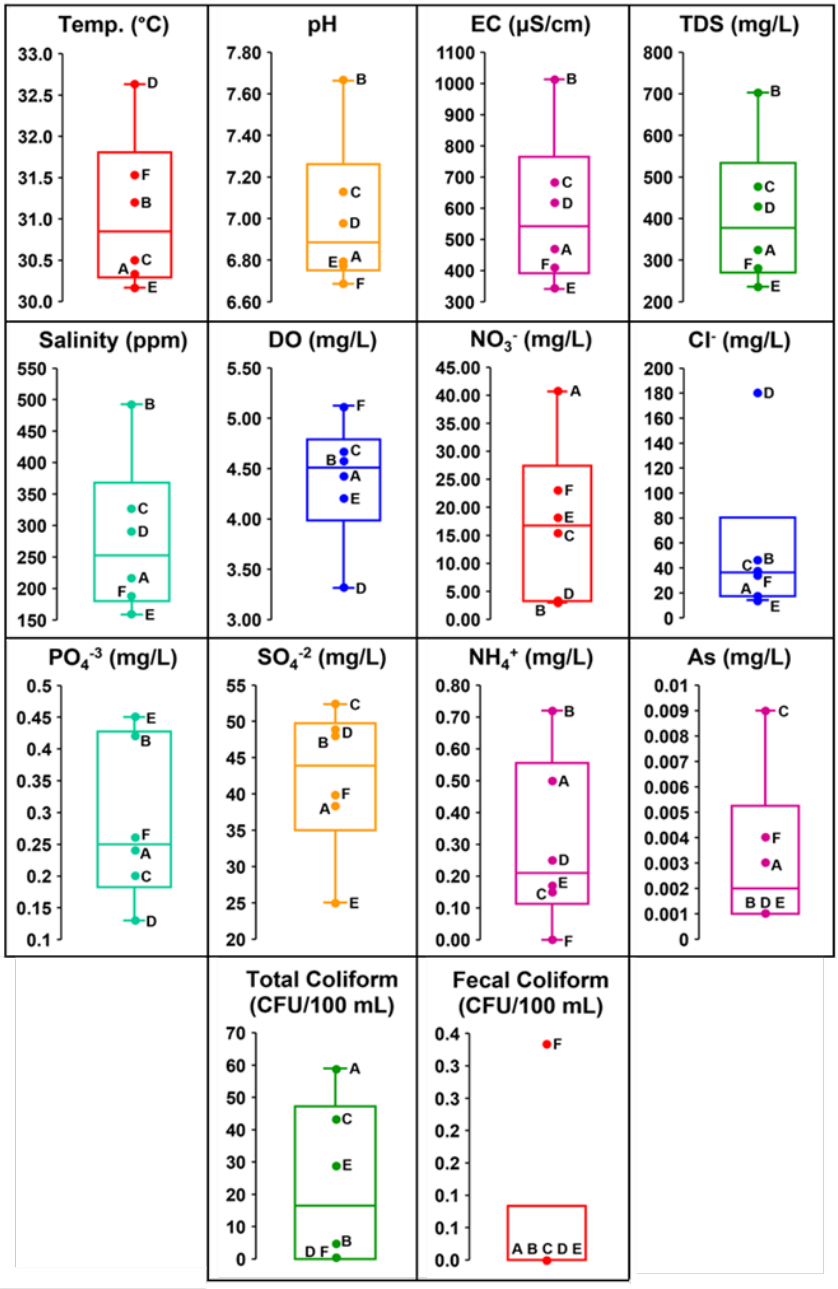
Legend

+	0.7	Very high positive correlation
+	0.5	High positive correlation
+	0.3	Medium positive correlation
+	0.1	Low positive correlation
	0	No correlation
-	0.1	Low negative correlation
-	0.3	Medium negative correlation
-	0.5	High negative correlation
-	0.7	Very high negative correlation

Outliers identified in chloride and fecal coliform plots. Temp.= temperature, EC= electrical conductivity, TDS= total dissolved solids, DO= dissolved oxygen, NO_3^- = nitrate, Cl^- = chloride, PO_4^{-3} = phosphate, SO_4^{-2} = sulfate, NH_4^+ = ammonium, As= arsenic.

Figure 14

Box and whisker charts (1.5 IQR outlier test). Outliers were identified in chloride and fecal coliform plots.



Temp= temperature, EC= electrical conductivity, TDS= total dissolved solids, DO= dissolved oxygen, NO_3^- = nitrate, Cl^- = chloride, PO_4^{-3} = phosphate, SO_4^{-2} = sulfate, NH_4^+ = ammonium, As= arsenic.

Geospatial Distribution of Contaminants

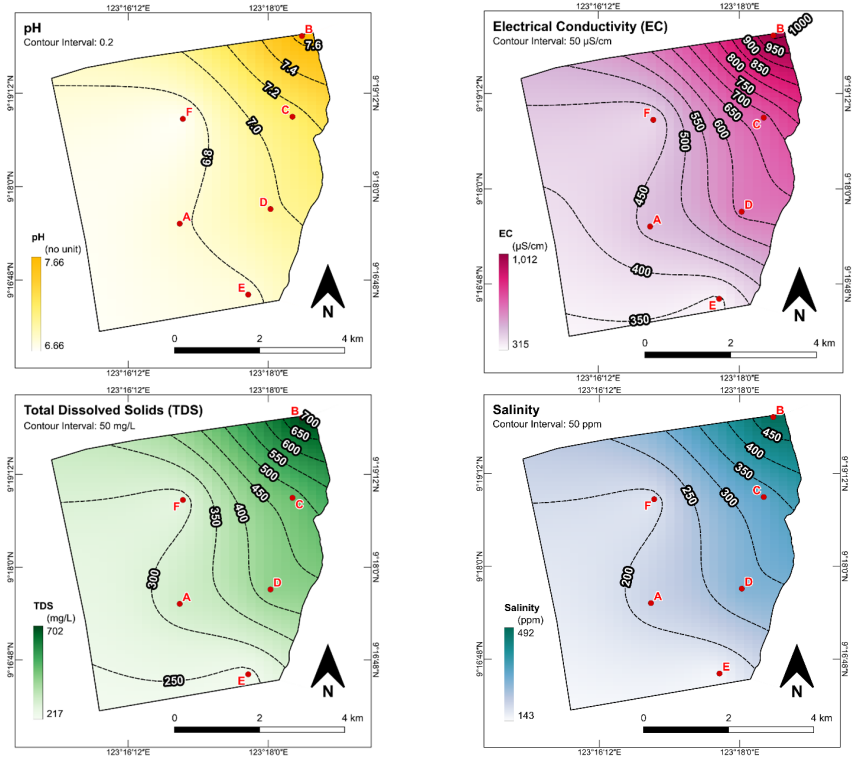
The concentration isopleth maps (Figures 15 to 16) show that pH, EC, TDS, salinity, and sulfate exhibit a northeastward increasing trend toward the coast. This suggests higher alkalinity and dissolved particles (salts, ions, minerals) in that direction. The highest chloride concentration was noted at Site D (Calindagan), an outlier. By excluding this outlier, chloride shows an increasing trend toward the northeast, similar to pH, EC, TDS, salinity, and sulfate (see linear regression plots, Figure 18).

DO levels show a decreasing trend from northwest to southeast where Site D (Calindagan) is located. This may be related to pollution from a long history of industrial land use in the Calindagan area. Nitrate concentrations show an increasing trend towards the west.

Total coliform levels do not appear to show a regional trend. The significant distances (>2 km) between the sampling sites and the likely localized impact from nearby septic tanks and sewer pipes (or sewage ditches) would preclude any regional correlation of the sampling sites.

Figure 15

Concentration Isopleth Maps of pH, EC, TDS, salinity, DO, and Nitrate.



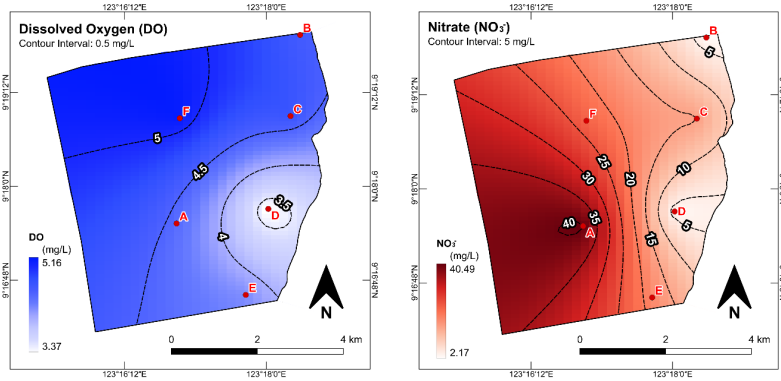
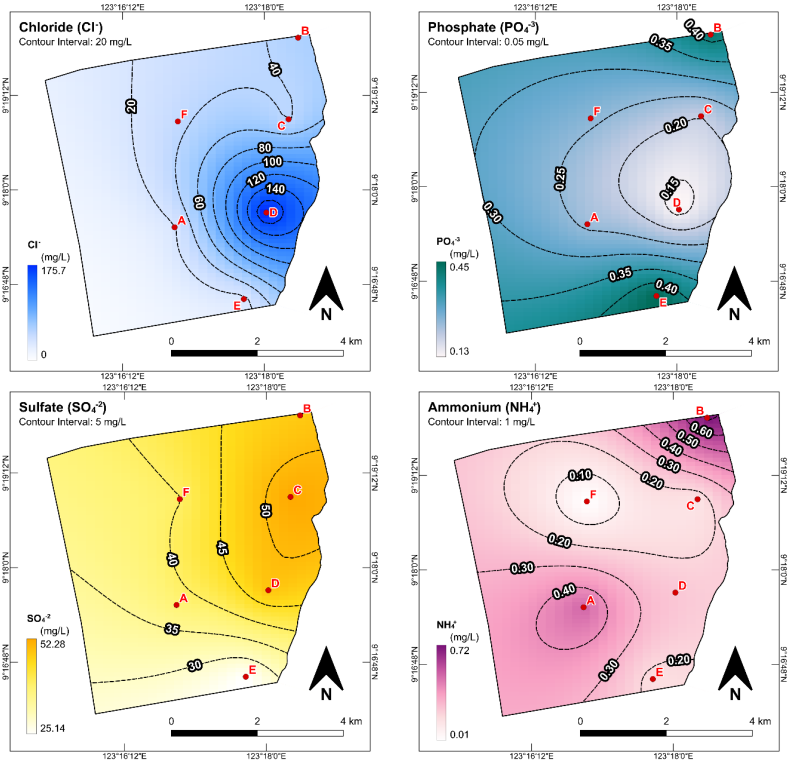
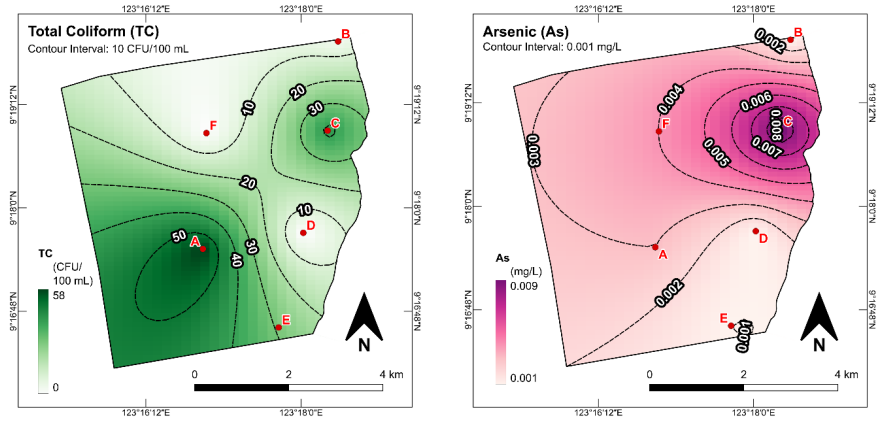


Figure 16

Concentration Isopleth Maps of Chloride, Phosphate, Sulfate, Ammonium, Total Coliform, and Arsenic.





Pollution Index of Groundwater (PIG)

Based on the PIG evaluation, Sites C and D are the least polluted ("insignificant pollution"). (See Table 5.) Sites A, B, and F have "low pollution," while Site E has "moderate pollution" for PIG calculations that exclude coliform. For PIG calculations that include coliform results (total and fecal coliform), groundwater at Sites D and F have insignificant pollution, while Site B has moderate pollution. Sites A, C, and E are classified as having "very high pollution." Calculations were based on Subba Rao (2011), with relative weight assignments (Rw) based on primary and secondary referenced standards and guidelines (see further discussion in section 4.7).

Table 5

Results of Pollution Index of Groundwater (PIG) Evaluation

Sampling Site	PIG Value (Without Coliform)	Classification (Without Coliform)	PIG Value (With Coliform)	Classification (With Coliform)
A (Junob)	1.2	Low Pollution	6.4	Very High Pollution
B (Bantayan)	1.4	Low Pollution	1.5	Moderate Pollution
C (Daro)	0.9	Insignificant Pollution	4.7	Very High Pollution
D (Calindagan)	0.6	Insignificant Pollution	0.5	Insignificant Pollution
E (Banilad)	1.5	Moderate Pollution	3.8	Very High Pollution
F (Batinguel)	1.1	Low Pollution	0.9	Insignificant Pollution

Insignificant pollution (PIG < 1.0), low pollution (1.0 < PIG < 1.5), moderate pollution (1.5 < PIG < 2.0), high pollution (2.0 < PIG < 2.5), and very high pollution (2.5 < PIG).

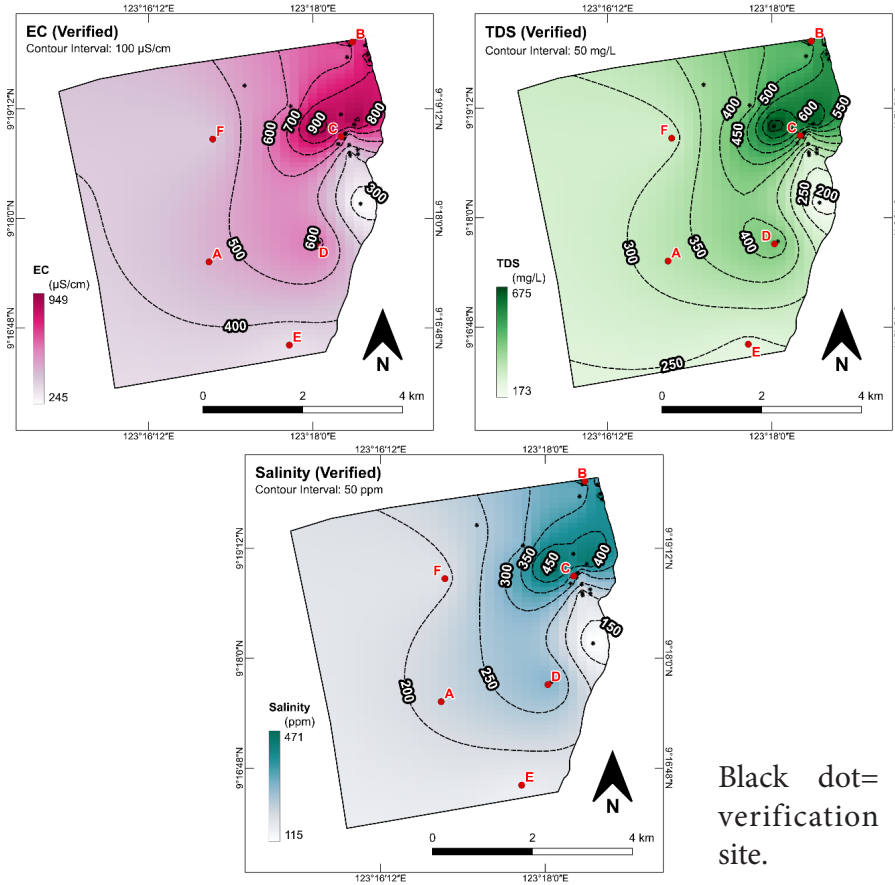
Discussion

Saltwater Intrusion

Spatial distribution (concentration isopleth) maps (see Figures 15-16) showed that the city's northeastern section had relatively higher pH, EC, TDS, and salinity levels. Linear regression of chloride values (excluding the outlier at Site D) also shows this trend (Figure 18). The readings were highest at Site B (Bantayan) and lowest at Sites A (Junob) and E (Banilad). This trend was verified by a subsequent supplemental survey using the EC500. Randomly tested community and domestic wells and natural springs confirmed the higher levels of EC, TDS, and salinity in the northeast section of the city (Figure 17). These results suggest some localized influence from saltwater (saltwater lens or intrusion?) in the city's northeast section.

Figure 17

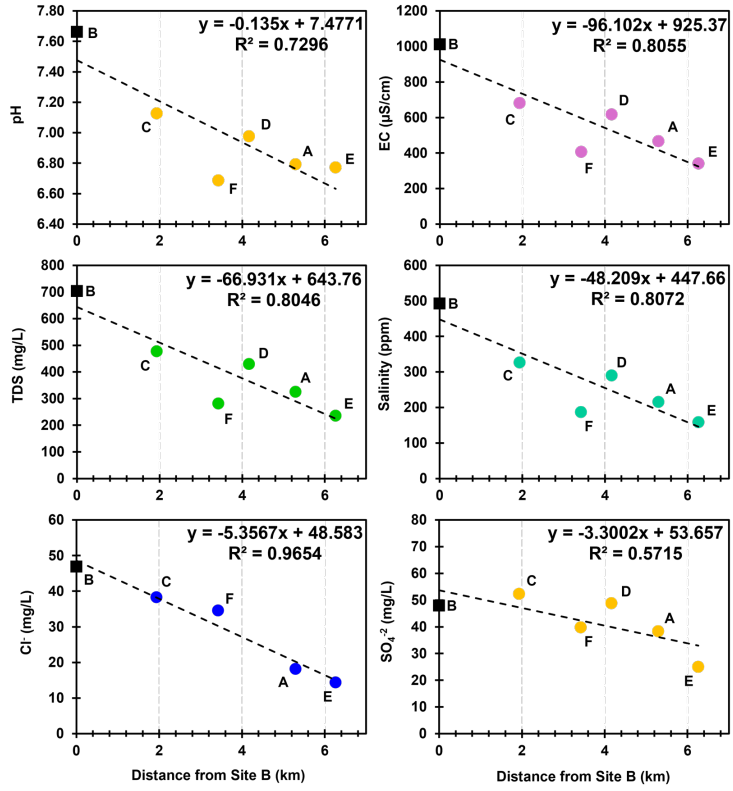
Concentration Isopleth Maps of EC, TDS, and Salinity with Verification



Black dot= verification site.

Figure 18

Linear Regression Scatter Plot of Concentration vs. Distance from the Northeast



Note: Site B is the reference point, as indicated by a black square. Site D (outlier) is excluded from the linear regression analysis for chloride. EC= electrical conductivity, TDS= total dissolved solids, Cl- = chloride, SO_4^{-2} = sulfate.

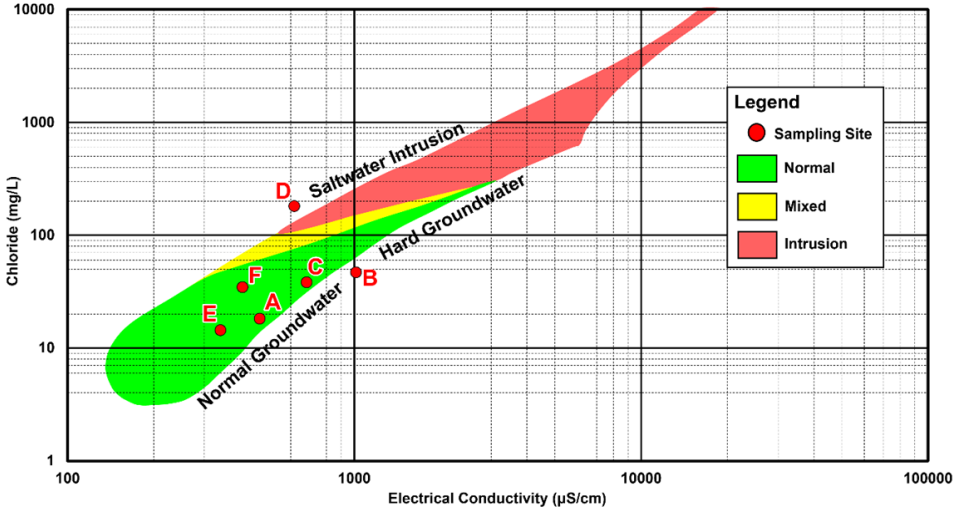
Based on a study of saltwater intrusion in British Columbia, Canada, Klassen et al. (2014) concluded that groundwater there was influenced by saltwater intrusion as characterized by chloride (Cl^-) concentrations exceeding 200 mg/L and EC levels exceeding 1,000 µS/cm. Chloride concentrations between 100-200 mg/L and EC between 600-2,000 µS/cm indicate a mixing of freshwater and saltwater. This is shown on a Cl^- versus EC log-log plot based on a study (Kelly 2005) of saltwater intrusion in Washington State, U.S.

Using this classification and upon plotting on the Kelly (2005) log-log plot, most of the sites in this study fall within the normal or freshwater zone (Figure 19). However, sites D (Calindagan) and B (Bantayan) appear to fall into transition zones. Site D with chloride at 181 mg/L and EC at 617

µS/cm plots slightly outside the zones but in the general area of the mixed (fresh and saltwater) zone. This contrasts with the fresher groundwater south of the Banica River, which has EC levels < 300 uS/cm (Caranto, 2005). Site B plots outside the normal and "hard groundwater" zones but has an elevated EC value (1,013 µS/cm) that correlates to elevated TDS and salinity, which distinguishes it from "normal" groundwater.

Figure 19

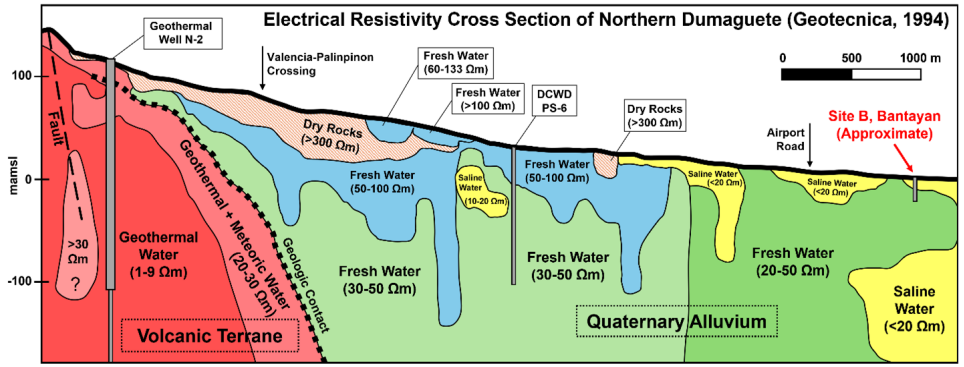
Chloride (Cl-) vs. Electrical Conductivity (EC) Scatter Plot, with Zones Classified as Normal Groundwater, Hard Groundwater, Saltwater Intrusion, and Mixed Groundwater (modified from Kelly, 2005).



It is postulated that the deep well (~80 ft) at Site B (Bantayan), and possibly other deep wells in the northeast section of the city, are pumping groundwater from a point that is close to the zone of dispersion or mixing zone where the deep saltwater below the coastline mixes with the shallower freshwater from inland. Alternatively, the well at Site B may be withdrawing water from a point near an adjacent lens or pocket of saline water in the subsurface (also described as a "fossil" or a "wedge" of saline water by Geotecnica, 1994). Most other shallower wells (e.g., 20 ft deep domestic wells) are likely pumping from the shallow freshwater lens above the mixing zone or lens of saline water. Figure 20 is an east-west cross-section of the georesistivity survey in the city's northern section (from Geotecnica, 1994), showing wedges or pockets of saline (low resistivity) groundwater.

Figure 20

The Electrical Resistivity Cross-section of Northern Dumaguete City (modified after Geotecnica, 1994)



The electrical resistivity survey generated by this cross-section was conducted along Rovira Drive from Barangay Bantayan to Barangay Ticala (in Valencia). Higher resistivity indicates fresher water, while lower resistivity (higher conductivity) indicates more saline water in the Dumaguete aquifer, mamsl= meters above mean sea level.

At Site B, the proximity to a subsurface saltwater body or interface is suggested by the relatively high groundwater pH, which is similar to the pH range (7.5 to 8.4) of seawater measured at Silliman Beach in Bantayan (Alcala et al., 2024). M. Alcala (personal communication, 3/20/24) also reported high TDS in the past decades in water from their community supply well, presumed to be about 80-100 feet deep, in the Silliman Park (Bantayan) residential community. (The well was located approximately 350 m south of Site B and decommissioned circa 2013.) However, since the low chloride concentrations at the two northeastern wells (Sites B and C) deviated from the characteristics of saltwater intrusion or mixing, additional investigation is necessary to prove proximity to the freshwater-saltwater interface or the possible onset of saltwater intrusion in the northeast margin of the aquifer. The chloride outlier (181 mg/L) at Site D in Calindagan suggests a similar situation to Site B—proximity to a saline water lens or the freshwater-saltwater mixing zone.

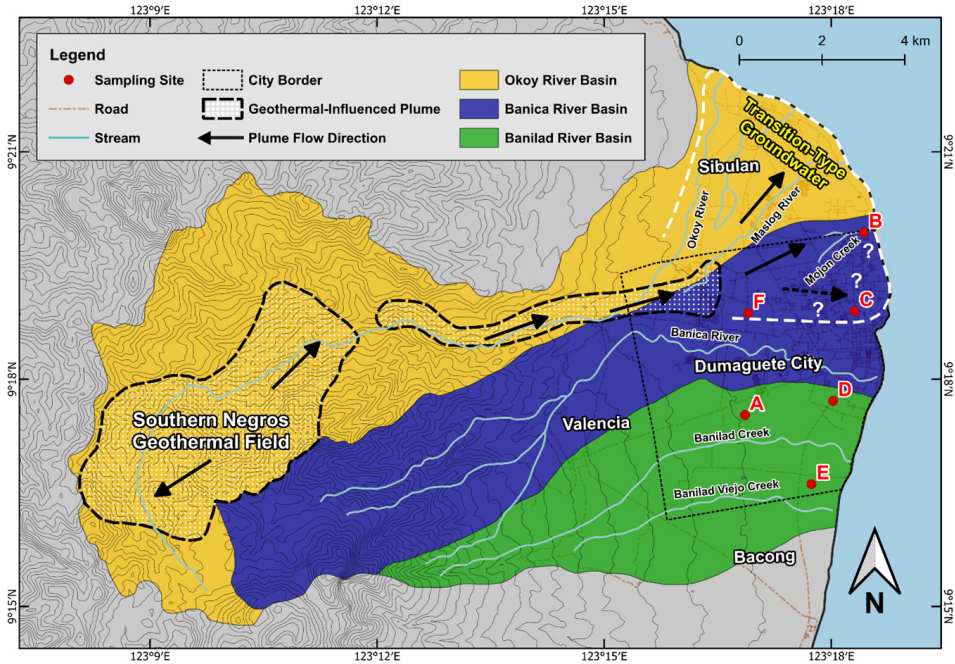
Hot Spring Waters

An alternative explanation for the relatively elevated EC, TDS, and salinity toward the northeast part of the city is the influence of hot spring (geothermal) waters. Caranto (2005) characterized the groundwater in the northern part of the city (and into Sibulan) as a mix of hot spring and meteoric waters (designated as "Ca+Mg-Cl+SO_4 water"). Smaller plumes influenced by hot spring waters ("Na+K-Cl+SO_4 water") were identified

in the northwest section of the city and further west in Valencia (Figure 3). A later study by Caranto et al. (2006) reported elevated Na, Li, B, Cl, and SO4 levels at DCWD production (public supply) wells 49, 53, 54, and 55 in the city's northwest section. This indicates an east-trending migration of a groundwater plume rich in geothermal-related ions towards the Dumaguete aquifer. Such ions may have contributed to the study area's relatively high EC, TDS, and salinity.

Figure 21

Migration of Geothermal-influenced Groundwater Plume from the SNGF to the Northeast, (modified after Caranto et al., 2006)



The White dashed line outlines the estimated extent of transition-type groundwater, hypothesized to extend toward Sites B in Bantayan and C in Daro. Other data sources: SWECO/LWUA (2001), NAMRIA, and PhilGIS. Topographic contour interval 20 m.

The relatively high sulfate (SO4-2) levels in the city's northeast section further support this alternative theory (see Figure 16). Sulfate may be associated with geothermal waters. It is a component of the Na+K-Cl+SO4 waters of hot spring origin (Caranto, 2005) and is highly correlated with pH, EC, TDS, and salinity in the Pearson product-moment correlation matrix (Figure 13). The SNGF waters were noted by Rae et al. (2011) to exhibit neutral to slightly alkaline characteristics, which could also explain the the mixed geothermal-meteoric waters and the postulated saltwater

dispersion zone, which could explain the relatively high EC, TDS, and salinity readings at Site B (Bantayan).

Geotecnica (1994) indicated in their geochemical study of the SNGF that there was concern that brine-water plumes from the higher elevations of the SNGF may be migrating toward the groundwater aquifer in the alluvial plain to the east, notably in the Bantayan area. The Geotecnica report also concluded that geothermal springs, such as surface- and ground-water arsenic, may contribute to contamination. This was their postulation for detecting arsenic in groundwater samples from a few wells in Dumaguete and several others in Valencia and Sibulan within the Okoy River basin. (Geotecnica's sampling area was concentrated in the western section of Dumaguete City and farther west in Valencia.)

This study detected arsenic at Sites C (Daro) and F (Batinguel). Assuming provenance from geothermal waters, this would extend the plume of geothermal fluid shown on the map of Caranto et al. (2006), which runs from the geothermal field in Valencia toward the east, between Okoy and Banica rivers (Figure 21). Further groundwater investigation (e.g., sampling additional wells at a higher frequency to account for seasonal fluctuation) is needed to confirm the extended plume of such geothermal-influenced waters.

A compilation of historical groundwater sampling results (the 1980s to early 1990s) by Geotecnica (1994) shows varying levels of less than 0.05 mg/L (the previous regulatory limit) of arsenic in artesian wells in the lowland areas adjacent to the SNGF (i.e., including the Dumaguete aquifer). Compared to the current arsenic drinking water standard of 0.01 mg/L, many historical sampling results exceeded the current standard. Thus, arsenic in groundwater remains a contaminant of concern.

Natural Minerals in Soil

The WHO (2011, 2022) reported that naturally occurring minerals primarily contribute to elevated sulfate concentrations in groundwater worldwide. The soils underlying Dumaguete are derived from weathering and erosion of volcanic rocks, which are known to be rich in sulfide minerals like pyrite (FeS2). The breakdown of sulfide minerals by water and oxygen generates sulfate compounds and ions in sediments and soils. Such a process offers an alternative origin of sulfate contamination in the groundwater in the study area. However, compared to the referenced drinking water standards, the sulfate concentrations in the study area, ranging from 25.06 to 52.37 mg/L, were below the threshold of 250 mg/L and are not a significant health

concern.

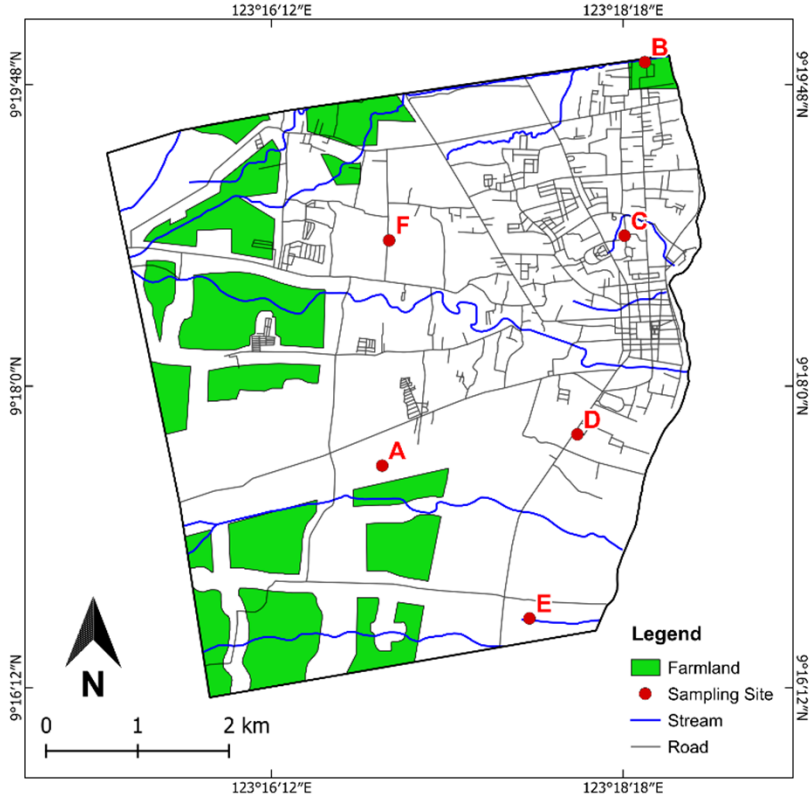
Sulfide mineral and volcanic deposits may also significantly contribute to elevated arsenic concentrations in groundwater (WHO, 2011, 2022). Arsenic is a component of several minerals, most commonly in arsenopyrite (FeAsS). In this study, Sites C and F (barangays Daro and Batinguel) exhibited relatively higher arsenic concentrations (0.009 and 0.004 mg/L, respectively), which can be attributed to subsurface volcanics or volcaniclastics. However, further study is warranted to investigate such a notion.

Agricultural Activity

Agricultural land use is one of the likely sources of contaminants in barangays Junob and Bantayan. Four of the six samples in this study had nitrate levels exceeding referenced standards. The proximity of Site A (Junob) to active agricultural fields in the area, coupled with the long history of agricultural use, can explain the elevated nitrate concentration in the groundwater sample from Site A. Furthermore, the geospatial distribution trend of increasing nitrate concentrations westwards (see Figures 15 and 22) correlates with the increasing agricultural land usage toward the west. The WHO (2011, 2022) identifies the application of inorganic nitrogenous fertilizers and manure in agriculture as the primary cause of nitrate contamination in groundwater. Similarly, the sample from Site B (Bantayan), although having lower nitrates, had higher ammonium (NH4+) and phosphate (PO4-3) levels, which reflect the long history of agricultural use of this area (as Silliman Farm).

Figure 22

Map of Agricultural Land Use in Dumaguete City (2013-2023), (modified after Emmanuel, 2017)



Urban Activity

The phosphate levels at all six sampling sites exceeded the referenced limits. Nitrate levels at four sites also exceeded the referenced limits. While the highest nitrate concentration was found at Site A (Junob), associated with active agricultural use, other sources from urban activities may account for the nitrate levels at the other sites. Wastewater disposal, including that associated with leaky septic tanks and sewer pipes, introduces nitrates from human and animal waste (WHO, 2011, 2022). Additionally, various industrial processes contribute to nitrate levels, including processing meat and crops and producing dairy (DENR, 2016).

Phosphates are found at higher concentrations in residential areas and locations with dense populations due to activities like sewage discharge and household laundry and cleaning practices (DENR, 2016). Thus, the phosphate and nitrate results for the study area reflect agricultural uses of

the land (e.g., at sites A, B, and D) and urban activities associated with increasing population.

Likewise, ammonium at Site B (Bantayan) may be associated with urban activity, mainly via infiltration from the polluted Mojon Creek. The recent study by Alcala et al. (2024) found relatively high levels of ammonia and other contaminants in the surface water samples collected from the mouth of Mojon Creek. The creek runs through densely populated sections with several industrial and commercial facilities. It exhibits intermittent high turbidity, dark coloration, and sewage odor indicative of contaminants, most likely including ammonia and ammonium. As a losing stream along much of its mainstem, the creek is likely contributing to groundwater contamination at Site B and other areas in Bantayan.

Site C in Daro is situated near Laguna Creek, a heavily polluted drainage ditch (Figure 23) and a likely source of contamination where it loses water as a losing stream into the aquifer. The high total coliform reading at Site C most likely originated from the highly polluted creek, which is only 90 m from the sampled well.

Figure 23

Images of (A) Mojon Creek and (B) Laguna Creek

Similarly, the total coliform results were high at Site E (natural spring), where the residential community has many septic tanks buried in highly permeable sandy soil and many sewage ditches. Animal waste from domestically-raised poultry and free-ranging cows was also ubiquitous in this community. Furthermore, this area in Banilad is characterized by a water table encountered at 1-2 m (and shallower) below grade. Such a combination of multiple land use, waste disposal, permeable soils, and shallow groundwater provide conditions conducive to a dispersion of bacteria and other contaminants into the aquifer.

The well at Site A (Junob) had the highest bacteria levels among all sampling sites. Since the area is now a construction site with no visible signs of bacterial sources, the origin of bacteriological contamination was perplexing. However, since it was known that the well was last used as a domestic well for a former residence, it is likely that an old, leaking septic tank may have existed nearby.

The very high correlation of total coliform with nitrate in the Pearson product-moment correlation matrix for this study further supports the notion that leaky septic tanks, sewage discharge (via leaky pipes and ditches), and other surface waste discharges are the likely sources of total coliform.

Site D in Calindagan presented a unique case. Relatively high temperatures suggest that surface water infiltration is attributed to warm, ponded sewage water near the well. Such a pond is heated by the sun daily and likely seeps rapidly into the groundwater, particularly along the well's steel casing. High chloride at Site D suggests the possibility of proximity to a saltwater lens or a zone of freshwater-saltwater mixing. Alternatively, the high chloride and low dissolved oxygen (DO) may indicate contamination from the sewage puddle and old septic tanks (the closest one being less than 10 m away). Other potential sources include an adjacent auto repair shop and commercial-industrial facilities within a hundred meters from this well. Although testing for this study revealed no current coliform issues, intermittent bacterial contamination is suspected. The high chloride content during sampling may be responsible for inhibiting bacterial growth. The owner reported that a previous lab analysis resulted in a high bacterial count. Such testing was initiated after her experience with bacterial infection, attributed to drinking water from the well.

A similar condition was observed at Site F in Batinguel, where a bacteriological sample yielded one colony-forming unit (CFU) of fecal coliform during one of the three trials. Such positive coliform result and the second highest nitrate levels among the six sites can be linked to the nearby (<7 m away) septic tank and sewage puddle very near the well at Site F.

Impact from Dumpsite

Of the six sampling sites, only Site F (Batinguel) would likely be impacted by leachate from the Dumaguete dumpsite located in barangay Candau-ay, 2.3 km west of Site F. Such location puts Site F in a hydraulically downgradient location from the dumpsite. The parameters for this study included the heavy metals arsenic, cadmium (Cd), lead (Pb), and mercury

(Hg), and ions (nitrate, chloride, phosphate, sulfate, and ammonium). Other physico-chemical parameters included pH, EC, TDS, salinity, and DO. Bacteriological (coliform) analysis was also added to the analyses. While most of these parameters can be attributable to the dump site, the analytical results and statistical evaluation did not indicate a significant trend or outliers. However, based on the results of the recent study by Romo (2024), which involved sampling six wells between the dumpsite and Site F of this study (a distance of 2.3 km), elevated levels of ammonium and phosphate were detected; such contamination was confirmed by low DO and high BOD levels. This suggests that a leachate plume has developed underneath the dumpsite and is likely migrating eastward. It is suggested that elemental and isotopic chemical investigations be conducted to confirm the provenance of contaminants from the dump site.

Overall Water Quality Assessment

The results of this study raise concerns for all stakeholders relying on groundwater as a potable water supply. Elevated levels of TDS at Site B exceeded safe drinking water standards, while sites C and D had high TDS levels that approached the 500 mg/L USEPA guideline. Five sites failed the minimum DO threshold of 5 mg/L. All six sites exceeded the DENR's phosphate threshold of 0.025 mg/L. Four sites exceeded the nitrate thresholds of 7 and 10 mg/L of the DENR and USEPA, respectively. Four sites exceeded the total coliform limit of 1 CFU/100 ml of the DOH. Arsenic levels were all below compliance levels, but one well (Site C) had arsenic at 0.009 mg/L, at the borderline of the drinking water standard of 0.01 mg/L.

Low DO levels typically indicate high contamination. Such low levels at most sites suggest the presence of additional contaminants, i.e., parameters not analyzed for in this study, such as volatile organics, oil-and-grease, polynuclear aromatic hydrocarbons (PAHs), and other organic compounds. The elevated phosphate at all sites makes the pumped water prone to algal growth. Nitrate concentrations in Junob, Daro, Banilad, and Batinguel exceeded the recommended limits of the DENR and the USEPA. Nitrate exceeding 10 mg/L in drinking water is a high risk for infants, i.e., prone to blue baby syndrome (MDH, 2023). High coliform in Junob, Daro, Banilad, and some total coliform in Bantayan, along with trace fecal coliform in Batinguel, is a cause for concern for well owners. Coliform in drinking water is associated with disease-causing microorganisms to which infants, children, elderly people, and people with weakened immune systems are most vulnerable (MDH, 2023).

The PIG statistical evaluation depended on a subjective weight assignment to the parameters. For this study, parameters with primary or mandatory drinking water standards were given a weight of 5, like TDS and metals; those with secondary standards were assigned a value of 4, while those with no standards were assigned a value of 3. The PIG results for geochemical parameters (coliform excluded) indicated that only one site (Site E, Banilad) was concluded to be moderately polluted, while the rest were of low to insignificant pollution. Site E (with a PIG value of 1.5, moderate pollution) was based on nitrate and phosphate exceeding the referenced standards, accompanied by other parameters that influenced the calculations. The other three "low pollution" (PIG values of 1.1, 1.2, and 1.4) sites had at least one parameter exceeding its referenced standard and other low-significance parameters. In contrast, the two "insignificant pollution" sites (with PIG values less than 1.0) had no exceedance.

Following the addition of bacteria levels in the recalculation, four sites were considered "moderate" (PIG value 1.5) and "very high" (PIG values 3.8, 4.7, and 6.4) in pollution indices. These results are influenced by bacterial contamination. This PIG method of evaluation would appropriately apply to a large and highly polluted region where regulatory "compliance averaging" is acceptable and does not require each hotspot or area of concern to be separately addressed or remediated.

Conclusions

Higher levels of pH, EC, TDS, salinity, and sulfate occur in the northeast section of the city. Notably, TDS in Bantayan exceeded drinking water standards. This phenomenon may be attributable to the transition-type (i.e., variably mixed geothermal and meteoric) groundwater influenced by geothermal waters in the upland areas, as characterized by Caranto et al. (2006), or proximity to a freshwater-saltwater mixing zone as indicated by the higher pH and chloride levels, and proximity to the coast. In Calindagan, the anomalous chloride level and elevated EC, TDS, and salinity may also be attributable to proximity to a freshwater-saltwater mixing zone; however, an alternative origin of chloride might be from urban pollution, particularly the local ponded sewage water and possibly old, leaky septic tanks in this historically commercial-industrial area.

Arsenic was detected in Batinguel and Daro, with the highest level in Daro (0.009 mg/L). Such concentration borders the regulatory limit (0.01 mg/L). The source of arsenic, along with higher sulfate levels, could be from upland geothermal waters such as hot springs. An alternative provenance

might be from the underlying volcanic and volcaniclastic rocks.

All phosphate results exceeded DENR guidelines for Class A water bodies, while nitrate exceeded referenced limits at four sites. All ammonium results were well below the referenced limits. Nitrate, phosphate, and ammonium varied from site to site, but a common contaminant source might be the historical agricultural land use combined with the rapid urbanization of the city, polluted ditches and creeks, and discharges from old, leaky septic and sewer systems. Increasing nitrate levels toward the west reflect the increasing agricultural use westward.

Coliform levels were significant in agricultural and residential areas (Junob, Daro, and Banilad), with trace presence at sites B and F (Bantayan and Batinguel, respectively). Such occurrence can be associated with nitrate sources, specifically historical agricultural use (e.g., fertilizers, animal waste discharge), leaking septic and sewer systems, and polluted puddles, ditches, and creeks.

The PIG evaluation indicated moderate to very high pollution indices in Junob, Daro, Banilad, and Bantayan. While overall pollution indices from the PIG evaluation were insignificant in Calindagan and Batinguel, localized sources of contamination were noted, such as old septic tanks and lingering sewage puddles near the wells. Applying PIG evaluation would be more useful in a highly contaminated and large region with numerous sampling points, where compliance is mandatory, and averaging is acceptable.

Recommendations

- Implement a water quality monitoring program using a network of selected public wells and shallow community and domestic wells; periodic sampling of such wells. Initial sampling parameters, particularly those wells closest to the former dumpsite, should include volatile organics, priority pollutant metals, PCBs, and pesticides. These are in addition to the parameters addressed in this study and are required by the DENR as mandatory or primary parameters. Subsequent monitoring will depend on contaminants identified in initial testing.
- Conduct a geochemical study to determine provenance: saltwater, geothermal, or mixed groundwater origin in the city's northern half. This may involve elemental geochemistry and comparison with the characteristics of hot spring waters in the geothermal field and saltwater from the sea. An isotope study would complement elemental geochemistry.

- Drill and install soil borings , piezometers, and monitoring wells to establish the hydrogeology of the auifer. Information should be collected from existing public and private deep wells to collect more data such as water levels, well screen depths, and well construction information. The monitoring wells can be used for groundwater quality monitoring.
- Identify the tributaries and delineate the drainage basins of the Banilad, Mojon, and Maslog creeks; determine the points along each stream (including the Okoy and Banica Rivers) where it becomes a gaining or losing stream. This would provide information to refine the aquifer model and assist in predicting contaminant movement to or from a stream.
- Collate all well information (e.g., drilling logs, pumping rates, pumping tests, water levels, etc.) for updated groundwater modeling and simulation using software like MODFLOW. Such modeling and simulation would provide updated water budgets, transient drawdowns, and long-term (steady-state) drawdowns.
- Identify areas with shallow wells at risk of pumping dry. Good management of well spacing, pumping rates, drawdowns, and basin-wide water levels would determine the long-term sustainability of the groundwater aquifer.

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References

Abellana, G. F., & Ilagan, A. R. (1995). *Chemical characteristics of water samples from artesian wells within the vicinity of the Dumaguete City dumpsite area at Candau-ay* [Bachelor's thesis, Silliman University].

Adimalla, N., Qian, H., & Nandan, M. J. (2020). Groundwater chemistry integrating the pollution index of groundwater and evaluation of potential human health risk: A case study from hard rock terrain of south India. *Ecotoxicology and Environmental Safety, 206,* 111217. https://doi.org/10.1016/j.ecoenv.2020.111217

Alcala, M.L, Aspilla, P.S., Bucol, A.A. & Parco, S. (2024). A site investigation of pollution along the Bantayan-Piapi coastline, Dumaguete City, Philippines [Manuscript submitted for publication].

Antonio, L. R., Aguilar, O. S., de Luna, E. A., Palaganas, U. M., & Maikoksoong, C. T. (1976). *Geology and mineral resources of Negros Island* [Report submitted to the Bureau of Mines]. Geological Survey Division, Bureau of Mines, Manila.

Asis, J. J. (1987). *A monitor study on the levels of DO, BOD, COD, H2S, Cl-, NH3, B, Na, K, and Hg of Okoy River in Negros Oriental* [Bachelor's thesis, Silliman University].

Aurelio, M. A., Dianala, J. D. B., Taguibao, K. J. L., Pastoriza, L. R., Reyes, K., Sarande, R., & Lucero, A. (2016). Seismotectonics of the 6 February 2012 Mw 6.7 Negros earthquake, central Philippines. *Journal of Asian Earth Sciences, 142,* 93-108. https://doi.org/10.1016/j.jseaes.2016.12.018

Caber, D. L., & Rivera, K. S. (2023). Hydro-Meteorological Hazards [PowerPoint slides]. Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA).

Caranto, J. A. (2005, April). Isotopic and chemical evidences of natural hot spring recharge into the Dumaguete Aquifer, Philippines. In *Proceedings World Geothermal Congress* (Antalya, Turkey).

Caranto, J. A., Pamatian, P. I., & Ogena, M. S. (2006). Chemical and isotopic trends in the Southern Negros geothermal field and the shallow groundwater aquifer in Dumaguete City due to long term exploitation [IAEA-TECDOC-CD--1507]. International Atomic Energy Agency (IAEA).

Carmona, A. R. A., & Ella, V. B. (2022). Exploring homogeneity among catchments for efficient province-wide watershed management in Negros Occidental, Philippines. *Journal of Environmental Science and Management, 25*(1), 20-33. https://ovcre.uplb.edu.ph/journals-uplb/index.php/JESAM/article/view/668

Casulla, M. A. A., Mizunaga, H., Tanaka, T., & Dimalanta, C. (2022). Imaging Crustal Features and Moho Depths Through Enhancements and Inversion of Gravity Data from the Philippine Island Arc System. *Progress in Earth and Planetary Science, 9*, 16. https://doi.org/10.1186/s40645-022-00473-8

Celenk, O., Flores, R. A. L., & dela Cruz, A. P. (1987). Geochemical characterization of epithermal alteration in Southeast Negros, Philippines. *Journal of Geochemical Exploration, 27*(1–2), 189-211. https://doi.org/10.1016/0375-6742(87)90011-2

De Lourdes Berrios Cintrón, M., Broomandi, P., Cárdenas-Escudero, J., Cáceres, J. O., & Galán-Madruga, D. (2023). Elucidating best geospatial estimation method applied to environmental sciences. *Bulletin of Environmental Contamination and Toxicology, 112*(6). https://doi.org/10.1007/s00128-023-03835-0

Department of Environment and Natural Resources (DENR), Philippines. (2016). *Administrative Order No. 2016-08: Water Quality Guidelines and General Effluent Standards* (WQG-GES).

Department of Environment and Natural Resources (DENR), Philippines. (2021). Administrative Order No. 2021-19: *Updated Water Quality Guidelines (WQG) and General Effluent Standards (GES) for Selected Parameters.*

Department of Health (DOH), Philippines. (2017). *Administrative Order No. 2017-0010: Philippine National Standards for Drinking Water (PNSDW).* https://www.fda.gov.ph/administrative-order-no-2017-0010-philippine-national-standards-for-drinking-water-of-2017/

Djebassi, T., Abdeslam, I., & Fehdi, C. (2021). Groundwater quality assessment, using pollution index of groundwater (PIG) from a semi-arid basin, Tebessa region (north-east of Algeria). *Journal of Materials and Environmental Science, 12*(8), 1046-1056. https://www.jmaterenvironsci.com/Document/vol12/vol12_N8/JMES-2021-12085-Djebassi.pdf

Duguma, T. A. (2023). RS and GIS analysis of the groundwater potential zones in the Upper Blue Nile River Basin, Ethiopia. *Journal of Hydrology: Regional Studies, 46*, 101344. https://doi.org/10.1016/j.ejrh.2023.101344

Dumaguete City Engineering Office. (n.d.). [Road Map of Dumaguete City] [Map].

Dumancas, C., Suarez, P., Juguilon, M. A., Lozada, R. F., Patula, M. T., Rubio, N., Tan, N., & Zamora, H. (1997). Nutrient water quality of Banica River in Dumaguete City, Philippines. *Silliman Journal, 38*(1&2).

Duran, W. S. (2023). *Physicochemical characterization of wastewater discharges of Dumaguete City* [Bachelor's thesis, Silliman University].

Emmanuel, J. (2017). *Safe Closure and Rehabilitation Plan, Candau-ay Dumpsite, Dumaguete City, Final Draft* [Submitted to the City of Dumaguete, December 2017].

Emmanuel, J. (2018). *Technical Evaluation of the Proposed Sanitary Landfill Site in Camanjac,* [Report submitted to the Technical Working Group on the Dumaguete dumpsite closure and SLF siting, March 4, 2018].

Gaikwad, S. K., Kadam, A. K., Ramgir, R. R., Kashikar, A. S., Wagh, V. M., Kandekar, A. M., Gaikwad, S. P., Madale, R. B., Pawar, N. J., & Kamble, K. D. (2020). Assessment of the groundwater geochemistry from a part of west coast of India using statistical methods and water quality index. *HydroResearch, 3,* 48-60. https://doi.org/10.1016/j.hydres.2020.04.001

Geotecnica Corporation. (1994). *Integrated watershed development plan and hydrological study for Okoy and Banica Watershed, SNGP* (EDC-93-147R). Final report volume II [Report submitted to PNOC-EDC, October 1994].

Golden Software (2024). *Surfer help*. Golden Software LLC (an online resource). https://surferhelp.goldensoftware.com/griddata/idd_grid_data_kriging.htm

Guevarra, D.G. & Inocian, K.E. (2024). *Geologic map of Negros Island* [Manuscript submitted for publication].

Jakóbczyk-Karpierz, S., & Ślósarczyk, K. (2022). Isotopic signature of anthropogenic sources of groundwater contamination with sulfate and its application to groundwater in a heavily urbanized and industrialized area (Upper Silesia, Poland). *Journal of Hydrology, 612*(C), 128255. https://doi.org/10.1016/j.jhydrol.2022.128255

Joodavi A., Aghlmand, R., Podgorski, J., Dehbandi, R., Abbasi, A. (2021). Characterization, geostatistical modeling, and health risk assessment of potentially toxic elements in groundwater resources of northeastern Iran. *Journal of Hydrology: Regional Studies, 37,* 100885. https://doi.org/10.1016/j.ejrh.2021.100885

Juguilon, M. A. R., & Zamora, H. L. (1994). *Water quality assessment of Banica River, Dumaguete City, Philippines* [Bachelor's thesis, Silliman University].

Keller, E. A. (2011). *Environmental geology* (9th ed.). Pearson Prentice Hall.

Kelly. D. (2005). *Seawater intrusion topic paper (final), Island County: WRIA 6 Watershed Planning Process 1-30*

Klassen, J., Allen, D. M., & Kirste, D. (2014). *Chemical indicators of saltwater intrusion for the Gulf Islands, British Columbia* [Report]. Department of Earth Sciences, Simon Fraser University. http://www.env.gov.bc.ca/ecocat/ [Ministry of Environment Ecological Reports Catalogue]

Lanzaderas, R. B. A. Q. (2018). *Geological assessment of the proposed sanitary landfill facility site of Dumaguete City Province of Negros Oriental.* Mines and Geosciences Bureau (MGB), Philippines.

Leach, T.M., & Bogie, I. (1982). *Overprinting of hydrothermal regimes in the Palimpinon Geothermal Field, Southern Negros, Philippines.*

Litke, D. W. (1999). Review of phosphorus control measures in the United States and their effects on water quality [U.S. Geological Survey Water-Resources Investigations Report 99-4007]. National Water-Quality Assessment Program.

Madhav, S., Ahamad, A., Kumar, A., Kushawaha, J., Singh, P., & Mishra, P. K. (2018). Geochemical assessment of groundwater quality for its suitability for drinking and irrigation purpose in rural areas of Sant Ravidas Nagar (Bhadohi), Uttar Pradesh. *Geology, Ecology, and Landscapes, 2*(2), 127–136. https://doi.org/10.1080/24749508.2018.1452485

Mallick, J., Singh, C. K., AlMesfer, M. K., Kumar, A., Khan, R. A., Islam, S., & Rahman, A. (2018). Hydro-geochemical assessment of groundwater quality in Aseer Region, Saudi Arabia. *Water, 10*(12), 1847. https://doi.org/10.3390/w10121847

Manalo, P. C., Dimalanta, C. B., Ramos, N. T., Faustino-Eslava, D. V., Queaþo, K. L., & Yumul, G. P. Jr. (2016). Magnetic signatures and Curie surface trend across an arc-continent collision zone: An example from Central Philippines. *Survey Geophysics, 37*(2), 407-422. https://doi.org/10.1007/s10712-016-9357-3

Maximo, R. P. R., Bernard, A., Maussen, K., Joiris, E., & Rebadulla, R. R. R. (2019). Geochemical studies of thermal waters from Kanlaon Volcano, Negros Island, Philippines. *Journal of Volcanology and Geothermal Research, 374*, 39–51. https://doi.org/10.1016/j.jvolgeores.2019.02.014

Mines and Geosciences Bureau (MGB). (2010). *Geology of the Philippines* (2nd ed.).

Minnesota Department of Health (MDH). (2022). Sulfate in well water [Fact Sheet]. https://www.health.state.mn.us/communities/environment/water/wells/waterquality/index.html

Minnesota Department of Health (MDH). (2023). Bacterial safety of well water [Fact Sheet]. https://www.health.state.mn.us/communities/environment/water/wells/waterquality/index.html

Minnesota Department of Health (MDH). (2023). Nitrate in well water [Fact Sheet]. https://www.health.state.mn.us/communities/environment/water/wells/waterquality/index.html

New Jersey Department of Health (NJDOH). (2016). Hazardous substance: Ammonia [Fact Sheet]. https://dep.nj.gov/wp-content/uploads/bears/nh3bb2000.pdf

Olivar, R. E. R., & Apuada, N. A. (2005). Hydro-Geophysical Model of the Southern Negros Geothermal Project, Central Philippines Based on Magnetotellurics Resistivity. *In Proceedings World Geothermal Congress* (Antalya, Turkey).

Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). (2020). *Climatological Normals of Dumaguete City* (1991-2020) [Data set].

Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). (2023). *Monthly and Annual Total Precipitation of Dumaguete City* (2004-2023) [Data set].

Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). (2023). *Monthly Temperature of Dumaguete City* (2004-2023) [Data set].

Pastoriza, L. R. (2017). *The geological characterisation and permeability evaluation of fractures in the Southern Negros Geothermal Field, Negros Island, Philippines* [Doctoral thesis, Durham University]. http://etheses.dur.ac.uk/12072/

Pastoriza, L. R., Holdsworth, R. E., McCaffrey, K. J. W., & Dempsey, E. (2018). Tectonic evolution of the southern Negros geothermal field and implications for the development of fractured geothermal systems. *Geofluids, 2018*, 6025038. https://doi.org/10.1155/2018/6025038

Pastoriza-Primaleon, L., McCaffrey, K. J. W., & Holdsworth, R. E. (2020). Fracture attribute and topology characteristics of a geothermal reservoir: Southern Negros, Philippines. *Journal of the Geological Society, 177*(5), 1092 - 1106. https://doi.org/10.1144/jgs2019-126

Philippine Institute of Volcanology and Seismology (PHIVOLCS). (2016). *Active and potentially active volcanoes of the Philippines* [Map].

Philippine Institute of Volcanology and Seismology (PHIVOLCS). (2022). *Philippine Seismic Network* [Map].

Quinamot, J. K. R., Angay, M. M. V., Ruelo, R. J. B., & Ruelo, H. B. (December 8-9, 2015). *Stratigraphy of southeastern Negros: Redefinition of Canlaon Volcanic Complex and Proposal for a Pliocene Lithostratigraphic Unit.* Presented at Geocon 2015.

Rae, A. J., Cooke, D. R., & Brown, K. L. (2011). The trace metal chemistry of deep geothermal water, Palinpinon geothermal field, Negros Island, Philippines: Implications for precious metal deposition in epithermal gold deposits. *Economic Geology, 106*(8), 1425–1446. https://doi.org/10.2113/econgeo.106.8.1425

Rae, A. J., Cooke, D. R., Phillips, D., & Zaide-Delfin, M. (2004). The nature of magmatism at Palinpinon geothermal field, Negros Island, Philippines: Implications for geothermal activity and regional tectonics. *Journal of Volcanology and Geothermal Research, 129*(4), 321–342. https://doi.org/10.1016/S0377-0273(03)00280-4

Ramirez, A. B. G. (2016). *A short discussion on the stratigraphy of southeastern Negros: In time and space* [Bachelor's thesis, Negros Oriental State University].

Rimando, R. E., Rimando, J. M., & Lim, R. B. (2020). Complex shear partitioning involving the 6 February 2012 Mw 6.7 Negros earthquake ground rupture in Central Philippines. *Geosciences,* 10(11), 460. https://doi.org/10.3390/geosciences10110460

Romo, F. J. F. (2024). *Characterization of leachate and potential groundwater contamination of the Candau-ay dumpsite in Dumaguete City, Philippines* [Bachelor's thesis, Silliman University].

Schmoll, O., Howard, G., Chilton, J., & Chorus, I. (Eds.). (2006). *Protecting groundwater for health*. World Health Organization & IWA Publishing.

Shaji, E., Santosh, M., Saratha, K.V., Prakash, Pranav, Deepchand, V., & Divya, B.V. (2020). Arsenic contamination of groundwater: a global synopsis with focus on the Indian Peninsula. *Geoscience Frontiers, 12* (3). https://doi.org/10.1016/j.gsf.2020.08.015

Sta. Ana, F. X. M., & O'Sullivan, M. J. (1988). Computer modelling of the Southern Negros geothermal field, Philippines. In Proc. 10th *New Zealand Geothermal Workshop.* University of Auckland.

Subba Rao, N. (2011). PIG: a numerical index for determination of groundwater contamination zones. *Hydrological Processes, 25*(13), 2076-2086. https://doi.org/10.1002/hyp.8456

Sunitha, V., Reddy, Y. S., Suvarna, B., & Reddy, B. M. (2022). Human health risk assessment (HHRA) of fluoride and nitrate using pollution index of groundwater (PIG) in and around hard rock terrain of Cuddapah, A.P. South India. *Environmental Chemistry and Ecotoxicology, 4*(2022), 113-123. https://doi.org/10.1016/j.enceco.2021.12.002

SWECO/LWUA (2001). *Water Resources Assessment and Development Plan 2000-2030 for Dumaguete City Water District, Negros Oriental Province* [Report submitted to LWUA and the DCWD].

Talabi, A. O., & Kayode, T. J. (2019). Groundwater pollution and remediation. *Journal of Water Resource and Protection, 11*(1), 1–19. https://doi.org/10.4236/jwarp.2019.111001

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy metal toxicity and the environment. In A. Luch (Ed.), *Molecular, clinical and environmental toxicology* (Vol. 101, Experientia Supplementum). Springer, Basel. https://doi.org/10.1007/978-3-7643-8340-4_6

U.S. Environmental Protection Agency. (2009). *National primary drinking water regulations*. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

Umezawa, Y., Hosono, T., Onodera, S., Siringan, F., Buapeng, S., Delinom, R., Yoshimizu, C., Tayasu, I., Nagata, T., & Taniguchi, M. (2008). Sources of nitrate and ammonium contamination in groundwater under developing Asian megacities. *Science of the Total Environment, 404*(2-3), 361-376. https://doi.org/10.1016/j.scitotenv.2008.04.021

von Biedersee, H., & Pichler, H. (1995). The Canlaon and its neighbouring volcanoes in the Negros Belt/Philippines. *Journal of Southeast Asian Earth Sciences, 11*(2), 111-123. https://doi.org/10.1016/0743-9547(94)00042-D

World Health Organization. (2011). *Guidelines for drinking-water quality* (4th ed.).

World Health Organization. (2022). *Guidelines for drinking-water quality: Fourth edition incorporating the first and second addenda.*

Wu, J., Bian, J., Wan, H., Ma, Y., Sun, X., (2021). Health risk assessment of groundwater nitrogen pollution in Songnen Plain. *Ecotoxicology and Environmental Safety, 207,* 111245. https://doi.org/10.1016/j.ecoenv.2020.111245

Yumul, G. P. Jr., Dimalanta, C. B., Marquez, E. J., & Queaño, K. L. (2008). Onland signatures of the Palawan microcontinental block and Philippine mobile belt collision and crustal growth process: A review. *Journal of Asian Earth Sciences, 34*(5), 610-623. https://doi.org/10.1016/j.jseaes.2008.10.002

Zhang, Q., Qian, H., Xu, P., Li, W., Feng, W., & Liu, R. (2021). Effect of hydrogeological conditions on groundwater nitrate pollution and human health risk assessment of nitrate in Jiaokou Irrigation District. *Journal of Cleaner Production, 298*, 126783. https://doi.org/10.1016/j.jclepro.2021.126783

Zhou, Y., Li, P., Xue, L., Dong, Z., & Li, D. (2020). Solute geochemistry and groundwater quality for drinking and irrigation purposes: A case study in Xinle City, North China. *Geochemistry, 80*(4), Supplement, 125609. https://doi.org/10.1016/j.chemer.2020.125609

Resilience and Coping Strategies of Junior High School Students in Dumaguete City

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Abstract

At the beginning of distance learning, there was a notable surge in referrals to the guidance office due to behavioral changes among junior high school students. Consequently, this study aims to explore the crucial association between the level of resilience and coping strategies among Junior High School students in Holy Cross High School Dumaguete. Despite considerable research on resilience and coping methods, there is a limited body of knowledge concerning Filipino Junior High School students. The survey included 253 students who responded to two standardized questionnaires. Based on the findings, it was observed that the respondents exhibited a high level of resilience. This is a positive attribute on the part of the respondents since it brings to light that they believe they can achieve their goals despite obstacles. They can return quickly to normal condition after a difficult situation or event. This manifests their high adaptability to changes that are inevitable in human existence. Additionally, their coping strategies leaned more towards an approach-oriented approach rather than avoidant coping strategies. When confronted with an unpleasant situation, they devise and execute strategies to alleviate the existing condition. They also think of it as part of the reality in life. Lastly, the study revealed a significant relationship between the level of resilience and coping strategies among the respondents.

Keywords: Junior high school, Students, Resilience, Coping strategies

Introduction

Adolescence is a period marked by confusion and exploration, where questions of independence and identity arise. During this phase, adolescents confront challenging decisions about academics, friendships, sexuality, gender identity, substance use, and alcohol consumption (Psychology Today, 2022). This transitional journey may induce anxiety related to physical

development, evolving relationships, and one's role in the broader world. While mild anxiety and common challenges are expected, serious mental health conditions may emerge during adolescence, emphasizing the importance of early intervention for optimal outcomes (Psychology Today, 2022).

Similar to physical health, mental well-being extends beyond the absence of disorders. Positive mental health dimensions, such as resilience, play a crucial role in an individual's ability to function competently amidst adversity (Murphey et al., 2013). Resilience, defined as the capability to navigate challenges or stress successfully, is associated with better-coping outcomes in adulthood, even after experiencing difficult circumstances in youth (Murphey et al., 2013). Resilience, a dynamic and developmental trait, has garnered attention in research, particularly during adolescence, a vulnerable period marked by risky behavior (Ahern et al., 2008).

Transitioning from childhood to young adulthood introduces new cultural and societal opportunities and expectations, accompanied by stressors such as romantic relationships, peer dynamics, academic pressures, and concerns about the future (Seiffge-Krenke & Klessinger, 2000). Coping strategies, developed and utilized by adolescents, are pivotal for handling stress and navigating the challenges inherent in this developmental phase. Adolescents benefit from support from peers and adults and their ability to manage everyday stressors independently, influencing their overall well-being (Marcova & Nikitskaya, 2013).

Historically, evidence consistently indicates that the peak incidence of mental health difficulties occurs during the transition from childhood to young adulthood, affecting up to 20% of adolescents (Kessler et al., 2005). The COVID-19 pandemic has exacerbated these challenges, impacting students' well-being due to school closures, social distancing, and the shift to online or blended learning. Studies reveal increased anxiety, depression, loneliness, sleep disturbances, academic difficulties, and externalizing problems among students during the pandemic (Cao et al., 2020; Gonzales et al., 2020; Son et al., 2020; Savitsky et al., 2020; Wang & Zhao, 2020; Salman et al., 2020; Labrague et al., 2020; Marelli, 2021; Kecojevic et al., 2020; Mahdy, 2020; Copeland et al., 2021). Social interactions declined due to restrictions, impacting students' connections with friends, classmates, and relatives.

De Guzman (2021) reports that amidst the initial COVID-19 surge in March 2020, the Philippines halted in-person classes for its 24.9 million public education students. President Rodrigo Duterte's "no vaccine, no classes" policy delayed the start of the new school year until October 2020. The education department implemented remote learning options, including

online platforms, educational TV and radio, and printed modules. However, social inequalities and inadequate resources at home have disproportionately affected many students and teachers, highlighting the challenges associated with the adopted learning approaches (De Guzman, 2021).

Over two years ago, everyone witnessed the COVID-19 pandemic, significantly changing our lives. Everyone has lived in the "new normal" setting for over two years. While some schools refused to open, Holy Cross High School (the research locale) continues to deliver education to its students. The school has two different learning modalities—offline (modular) and online. This is to ensure that "No Child Is Left Behind." For Offline Learning, teachers prepare comprehensive modules so the learners can still understand the lesson even in their absence. It is given to those not fortunate enough to have strong internet access at home. Another form of learning modality that the school offers is online learning. In this mode, teachers use an effective integrated set of interactive online services that can bring out the best in their students.

Since beginning distance learning, the Guidance Office has significantly increased referrals, especially in the Junior High School Department. These referrals came from teachers and parents who have observed the change in behaviors among their students and children. Some common concerns include absenteeism and failure to submit classwork on time. There were also cases from the Guidance Office that have been referred to psychologists since the referred students manifested signs of depression. Most of the students' complaints during the interviews were about their anguish due to the lockdowns. Some students, even those who excelled in their coursework before the pandemic, have lost motivation to attend online classes.

Hence, this study aims to investigate the important association between the level of resilience and coping strategies of Junior High School students in Holy Cross High School. While much research on resilience and coping methods has been completed, few have been conducted with Filipino Junior High School students, particularly in Dumaguete City. The study's findings could form the basis for a particular Guidance and Counseling Program that is beneficial during challenging times.

Materials and Methods

Research Design

This research employed a descriptive-correlational design, primarily

describing and establishing relationships among the investigated variables. As Lappe (2000) and Salkind (2010) advocate, a descriptive-correlational design is well-suited for portraying relationships between variables without implying cause-and-effect connections. This design is particularly valuable when elucidating how one phenomenon is interconnected with others, especially in cases where the researcher lacks control over independent variables presumed to impact the dependent or outcome variable.

The study began by describing the respondents' profiles, encompassing age, sex, and grade level. Following this, the level of resilience among the respondents was evaluated using the Connor–Davidson Scale (CD-RISC-10). Subsequently, the coping strategies employed by the respondents were delineated based on the Brief-COPE Inventory. Finally, correlational analysis was undertaken to ascertain whether a significant relationship exists between the level of resilience and coping strategies among the respondents.

Research Participants

The respondents for this study comprised officially enrolled Junior High School students for the School Year 2021-2022. The total number of students in Grades 7 to 10 was 281. Among them, 253 students participated in online classes, while the remaining 28 were in offline or modular classes. Only students taking online classes were considered participants in the study to eliminate the learning delivery modality as a source of variance. Due to the manageable number of participants, a complete enumeration approach was employed.

Research Instrument

This research employed two distinct research instruments. The first instrument was the Connor–Davidson Resilience Scale (CD-RISC-10). Comprising ten items selected from the original 25 of the CD-RISC-25 scale, this instrument measures an individual's resilience or ability to recover after encountering stressful events, tragedy, or trauma. The second instrument utilized was the Brief-COPE, a condensed version of the COPE (Coping Orientation to Problems Experienced) Inventory. COPE Inventory is a self-report questionnaire designed to evaluate a broad spectrum of coping responses and is well-regarded for its validation and widespread usage (Garcia et al., 2018).

Data Gathering Procedure

Throughout the distance learning period, the Guidance Office of Holy Cross High School has recorded increased referrals from teachers and parents. Most reported issues include students' absenteeism and failure to submit class works on time. There were also cases from the Guidance Office that have been referred to psychologists since the referred students manifested signs of depression. Most of the students' complaints during the interviews were about their anguish due to the lockdowns. Some students, even those who excelled in their coursework before the pandemic, are now unmotivated to attend online classes. The research process involved a series of formal communications to obtain necessary permissions and consents. Initially, formal letters of request were composed and sent to the School Director and School Principal of Holy Cross High School, seeking permission to conduct the study among their Junior High School students. Upon receiving approval from both authorities, subsequent formal letters were dispatched to the parents, seeking their consent for their children's participation in the study. The study was conducted online, and parents were provided with a Data Privacy Consent Form. After receiving parental approval, the respondents were sent a Research Informed Consent Form through their Microsoft Teams Account, requesting their approval to participate in the study. Following the approvals and consents, the two-part questionnaire, comprising the Connor–Davidson Resilience Scale and the Brief COPE Inventory, was distributed to the respondents.

Throughout the distance learning period, the Guidance Office of Holy Cross High School has recorded increased referrals from teachers and parents. Most reported issues include students' absenteeism and failure to submit class works on time. There were also cases from the Guidance Office that have been referred to psychologists since the referred students manifested signs of depression. Most of the students' complaints during the interviews were about their anguish due to the lockdowns. Some students, even those who excelled in their coursework before the pandemic, are now unmotivated to attend online classes. The research process involved a series of formal communications to obtain necessary permissions and consents. Initially, formal letters of request were composed and sent to the School Director and School Principal of Holy Cross High School, seeking permission to conduct the study among their Junior High School students. Upon receiving approval from both authorities, subsequent formal letters were dispatched to the parents, seeking their consent for their children's participation in the study. The study was conducted online, and parents

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Data Analysis Procedure

To assess the level of resilience, the scores for each item were added up, and then the column totals were aggregated to obtain the CD-RISC score. Interpretation of results followed the scale: 0 to 10 signifies not true at all; 11 to 20 indicates rarely true; 21 to 30 suggests sometimes true; 31 to 40 implies often true, while 41 to 50 signifies true nearly all the time. Regarding resilience level, not true at all was considered very low; rarely true as low; sometimes as moderate; often true as high; and true nearly all the time as very high.

For the coping strategies, the data were analyzed using a weighted mean. Groupings were established based on intervals for a four-point scale to facilitate interpretation: 1.00–1.74 for "I haven't been doing this at all"; 1.75–2.49 for "I've been doing this a little bit"; 2.50–3.24 for "I've been doing this a medium amount"; and 3.25–4.00 for "I've been doing this a lot."
Lastly, Spearman's rho was employed to determine the extent of the relationship between the level of resilience and coping strategies. This statistical tool was chosen because the correlated data were both in the ordinal level of measurement. For a significant relationship to be considered, the p-value had to be equal to or lesser than the alpha, set at 0.05 in this study.

Ethical Considerations

For the advancement of this study, ethical approval was secured from and granted by the University Research Ethics Committee of Silliman University. This step was taken to guarantee that all tests, procedures, and information gathered in this study were conducted in the best interest of the participants. To ensure transparency and uphold ethical standards, parental consent and informed consent were obtained from all respondents before they participated in the study and data-gathering processes.

A commitment to confidentiality was maintained throughout the study, with students' responses treated with the utmost discretion. In

processing and interpreting the data, the participants' identities will remain anonymous, safeguarding their privacy and confidentiality. This ethical framework underscores the dedication to conducting research with integrity and ensuring the well-being and rights of the participants.

Results

Demographic Profile

In terms of gender, the results indicated a higher representation of female respondents, comprising 154 individuals (60.87%), surpassing their male counterparts. Regarding grade level, it is evident that most respondents were in Grade 10, constituting 81 individuals (32.03%) out of the total respondents. Following Grade 10, Grade 9 had 68 respondents (26.88%), Grade 7 had 57 respondents (22.53%), and Grade 8 had 47 respondents (18.58%).

Level of Resilience

The overall level of resilience among the respondents was high. This is evident in the aggregate weighted mean presented in Table 1. Also, most (70%) items were rated as high. Although the weighted means of items with such ratings varied, ranging from 2.42 to 2.98, all fell within the verbal description of high. This is a positive attribute on the part of the respondents since it brings to light that they believe they can achieve their goals despite obstacles. They can return quickly to normal conditions after a challenging situation or event. This manifests their high adaptability to changes that are inevitable in human existence.

Table 1
Level of Resilience

Statements	Mean	SD	Interpretation
1. I believe I can achieve my goals, even if there are obstacles.	2.98	1.19	High
2. I tend to bounce back after illness, injury, or other hardships.	2.82	1.30	High
3. I can adapt when changes occur.	2.75	0.88	High
4. Under pressure, I stay focused and think clearly.	2.67	0.99	High
5. I am not easily discouraged by failure.	2.58	1.14	High
6. Having to cope with stress can make me stronger.	2.42	1.17	High
7. I can handle unpleasant or painful feelings like sadness, fear, and anger.	2.42	1.29	High
8. I think of myself as a strong person when dealing with life's	2.38	1.22	Moderate
9. challenges and difficulties.			Moderate
10. I can deal with whatever comes my way.	2.27	0.76	
11. I try to see the humorous side of things when I am faced with problems.	2.24	1.06	Moderate
Aggregate	2.55	0.78	High

Coping Strategies

As indicated in Table 2, coping orientation to problems experienced is classified into avoidant and approach. In the avoidant category, the aggregate weighted mean is 2.15, indicating that respondents have used avoidant strategies to a moderate extent. In other words, they are using these strategies to a moderate degree. In terms of utilizing the approach as a mechanism in dealing with unpleasant situations, unlike avoidant, they use it to a medium level. This is reflected in the aggregate weighted mean of 2.76. Hence, it can be deduced that the respondents are more approach-oriented than avoidant. When confronted with an unpleasant situation, they will resort to coming up and executing strategies that could alleviate the existing condition. They also think of it as part of the reality in life.

Table 2
Coping Mechanism

Avoidant	Mean	SD	Interpretation
1. I've been doing something to think about it less, such as going to movies, watching TV, reading, daydreaming, sleeping, or shopping.	2.88	1.03	Medium
2. I've been turning to work or other activities to take my mind off things.	2.80	0.89	Medium
3. I've been saying things to let my unpleasant feelings escape.	2.63	1.09	Medium
4. I've been criticizing myself.	2.48	1.03	A bit
5. I've been expressing my negative feelings.	2.43	1.04	A bit
6. I've been blaming myself for things that happened.	2.25	0.93	A bit
7. I've been refusing to believe that it has happened.	2.23	1.00	A bit
8. I've been giving up the attempt to cope.	2.21	0.88	A bit
9. I've been saying to myself, "This isn't real".	1.82	0.95	A bit
10. I've been giving up trying to deal with it.	1.81	0.74	A bit
11. I've been using alcohol or other drugs to make myself feel better.	1.17	0.43	Not at all
12. I've been using alcohol or other drugs to help me get through it.	1.12	0.39	Not at all
Aggregate	**2.15**	**0.42**	**A bit**
Approach			
13. I've been trying to come up with a strategy about what to do	3.13	0.89	Medium
14. I've been accepting the reality of the fact that it has happened.	3.02	0.75	Medium
15. I've been concentrating my efforts on doing something about the situation I'm in.	2.98	0.84	Medium
16. I've been thinking hard about what steps to take.	2.92	1.02	Medium
17. I've been taking action to try to make the situation better.	2.86	0.69	Medium
18. I've been getting help and advice from other people.	2.85	1.09	Medium
19. I've been looking for something good in what is happening.	2.69	0.93	Medium
20. I've been trying to see it in a different light to make it seem more positive.	2.66	1.05	Medium
21. I've been trying to get advice or help from other people about what to do.	2.62	0.99	Medium
22. I've been getting comfort and understanding from someone.	2.53	1.29	Medium
23. I've been learning to live with it.	2.47	0.89	A bit
24. I've been getting emotional support from others.	2.34	1.01	A bit
Aggregate	**2.76**	**0.59**	**Medium**

Neither Avoidant nor Approach			
25. I've been praying or meditating.	3.01	1.02	Medium
26. I've been making jokes about it.	2.44	1.12	A bit
27. I've been trying to find comfort in my religion or spiritual beliefs.	2.38	0.89	A bit
28. I've been making fun of the situation.	1.93	0.87	A bit
Aggregate	**2.86**	**0.69**	**A bit**

Relationship Between Level of Resilience and Coping Strategies

As shown in Table 3, a significant relationship exists between resilience and each of the coping orientations. This is manifested in the respective p values, which are lesser than the alpha at 0.05 level of significance. This implies that there is a need to do something to keep avoidant at its low level and, at the same time, keep the approach to a high level to enhance one's level of resilience.

Table 3

Relationship between Level of Resilience and Coping Strategies

Variables	Rs	p
Resilience & Avoidant	-0.26	0.00*
Resilience & Approach	0.53	0.00*
Resilience & Neither Avoidant nor Approach	0.34	0.00*

Discussion

High Resilience Among Participants

In general, students demonstrated a notably high level of resilience as assessed by the Connor–Davidson Scale. This positive characteristic among the respondents reflects their confidence in their capacity to achieve goals despite obstacles, swiftly return to normalcy following challenging situations or events, and their adeptness at adapting to the inevitable changes in human existence. This finding aligns with the research of Delvecchio et al. (2022), indicating that while most children tend to revert to normal behavior after stressful events, some are more susceptible to developing psychological issues (Orgilés et al., 2021). Understanding the coping

ability to overcome challenges sheds light on the variations in how children navigate adversity. Moreover, the data reveal their ability to maintain focus under pressure, signifying robust resistance to failure and negative emotions. Due to their elevated sense of positivity, they exhibit resilience, bouncing back stronger after being affected by adverse phenomena. This resonates with Rutter's Resilience Theory in 2006, which defines resilience as "An interactive concept concerned with the combination of serious risk experiences and a relatively positive psychological outcome despite those experiences" (Rutter, 2006).

However, some responses indicated that respondents perceived themselves as in the middle range on the resiliency scale, viewing themselves as neither highly nor poorly resilient in confronting life's challenges. These aspects may warrant attention and improvement, as adverse phenomena are inherent to human existence, as illustrated in Rouse, Ingersoll, and Orr's (1998) study on the relationship between adolescent high-risk behavior and resilience. The researchers concluded that resilient youth were less likely to engage in new risky behaviors, although they were not exempt from experiencing troublesome behaviors and emotions. According to Seligman's (1990) 3Ps Theory, understanding how thoughts, mindset, and beliefs influence experiences can contribute to resilience and the ability to rebound from life's challenges.

Moderate Coping Strategies

Earlier, it was illustrated that respondents have been utilizing avoidant strategies to a moderate degree. This implies that they indulge in self-critique, self-blaming, denial of occurrences, abandonment of coping efforts, and the conviction that nothing unpleasant has transpired. Coping strategies vary based on the nature of stressors and the individual's developmental stage (Zimmer-Gembeck & Skinner, 2011). A recent study involving a substantial sample of UK adults revealed that all three types of coping strategies were significantly associated with heightened anxiety and depressive symptoms at the commencement of the lockdown (Fluharty, Bu, Steptoe, & Fancourt, 2021). Factors such as the abrupt closure of schools, uncertainty regarding reopening, the adoption of distance learning, and societal crises have negatively impacted the mental well-being of children and adolescents (Bozkurt et al., 2020; Ghosh et al., 2020; Guessoum et al., 2020; Lee, 2020). An examination of children's learning experiences during the COVID-19 pandemic underscored escalated feelings of anxiety and stress (Di Pietro et al., 2020).

Regarding utilizing the approach as a coping mechanism for unpleasant situations, respondents engage in it to a medium extent. This suggests that the respondents lean more towards approach than avoidance. This inclination is evident in the prevalence of statements/items with medium verbal descriptions. Faced with unpleasant situations, they tend to formulate and implement strategies to alleviate the existing condition, viewing it as part of life's reality. Moreover, they adopt an optimistic outlook by seeking positive aspects of what happened, believing that lessons from such experiences can strengthen them in the future. Additionally, respondents acknowledge the substantial support and advice from others in helping them cope with unpleasant situations.

Beyond the two distinct coping orientations, a set of items that fall neither into the avoidant nor approach categories were also explored. Among these, making jokes about the situation, finding comfort in one's religion, and making fun of the situation are used to a small extent. Praying and meditating are employed to a medium level. This aligns with Ang and Diaz's (2017) study at Bulacan State University, which explored Filipinos' perceptions, resilience, and coping strategies in the face of frequent disasters such as typhoons and floods. Resilience among respondents often relies on faith-based practices and traditional support systems like family and community. The respondents believe in having a way to deal with problems, reflecting the Filipino quality of "lakas ng loob" (inner strength) (Ignacio, 2010). Thus, the results indicate that Filipinos' manifestation of resilience and coping strategies is influenced by their perception of the aftermath or effects of a disaster.

Significant Relationship Between Resilience and Coping Strategies

The Spearman's rho correlation coefficients indicate a significant relationship between resilience and each of the coping orientations, as reflected in the respective p values being less than the alpha at the 0.05 level of significance. A similar study conducted by Nicomedes et al. (2020) at the Polytechnic University of the Philippines found that individuals maintaining tolerance despite negative influences on their coping tended to develop negative resilience. Enduring past adversities and new challenges with negative behavior, thoughts, and a pessimistic world perspective characterize negative resilience. Conversely, despite facing adversities, some individuals tend to develop healthier resilience. When encountering new challenges, they cope positively, often relying on family, religious spirituality, or community support. These individuals may initially go through a phase

of negative resilience, which eventually transforms into positivity.

This outcome is consistent with research by Valladolid (2021), which affirms the positive association between resilience and well-being. However, the link was not influenced by the type of coping strategy employed. The discovery of a positive correlation between resilience and well-being resonates with other relevant studies indicating that resilience contributes to positive mental health (Malkoc & Yalcin, 2015; Souri & Hasanirad, 2011; Chow et al., 2018; Yildirim & Arslan, 2020; Konaszewski et al., 2021; Chen, 2016). Furthermore, behavioral avoidance strategies were linked to negative psychological well-being. The study also uncovered a positive correlation between resilience and the approach to coping strategy, suggesting that resilient individuals utilize positive coping mechanisms. This finding aligns with other research demonstrating a positive association between resilience and positive coping strategies.

Moreover, individuals with higher levels of depression were found to have lower resilience and were more likely to engage in avoidant coping strategies. In contrast, those who employed more problem-focused coping strategies reported lower levels of depression. However, this study revealed that neither approach nor avoidant coping strategies moderated the relationships between resilience and well-being. Similarly, Bonner (2015) discovered that coping diversity did not align with measures of perceived stress, mental health, physical health, or the primary method of measuring coping diversity. Overall, elevated levels of perceived stress were linked to poorer mental and physical health outcomes. However, these relationships were not influenced by coping self-efficacy or coping diversity.

Conclusion

Regarding demographics, the dominant population was 14 years old. The youngest respondents were 11 years old, and the eldest were 17 years old. Second, The female respondents comprised the larger percentage of the respondents enrolled during the school year when the study was conducted. Out of the total population, there are more female respondents, 154 (60.87%) compared to male respondents, who are only 99 (39.13%). Lastly, the majority of the respondents were Grade 10 students.

Concerning the level of resilience, the respondents' overall level of resilience is high. This is a positive attribute on the part of the respondents since it brings to light that they believe they can achieve their goals despite obstacles. They can return quickly to normal condition after a difficult situation or event. This manifests their high adaptability to changes that are

inevitable in human existence.

Concerning the respondents' coping strategies, the results reveal that the respondents are more approach than avoidant coping strategy. This is reflected in the approach coping strategy's aggregate weighted mean of 2.76, which means medium. The preponderance of the statements/items with medium verbal descriptions exemplifies this phenomenon. When confronted with an unpleasant situation, they will devise and execute strategies to alleviate the existing condition. They also think of it as part of the reality in life.

As to the relationship between the level of resilience and coping strategies, a positive relationship exists between each pair of variables, indicating that the same movement of the other accompanies any movement in one variable. Hence, as one's score/rating in approach and neither avoidant nor approach go higher, so does resilience. This implies that there is a need to do something to keep avoidant at its low level and, at the same time, keep the approach to a high level to enhance one's level of resilience. Thus, there is a significant relationship between level of resilience and coping strategies among the respondents.

Recommendation

The overall level of resilience of the respondents is high. Nevertheless, it is highly recommended that the resilience level of respondents be raised from high to very high. One way to do this is to have a Registered Guidance Counselor in Holy Cross High School who will facilitate the conducting of profound programs to enhance the level of resilience of students.

A thoroughly planned and well-organized orientation program or workshop on the different types of coping strategies is also recommended. It can help them understand the consequences of involving themselves in avoidant coping and the advantages of approach coping.

This study has established a significant relationship between level of resilience and coping strategies. Thus, the researcher then recommends that the school hire a Registered Guidance Counselor who will design a training program wherein the junior high school students will undergo training on addressing issues such as resilience and coping.

The result of this study needs to be shared with administrators, teachers, and parents so that they can better understand their students' / children's challenges and better assist them properly. It is recommended that further studies be made on exploring other techniques to enhance one's level of resilience and coping strategies aside from the ones explored in this study.

Furthermore, this study could be used as a basis for studies on the transition from online classes to face-to-face classes.

References

Ahern, N. (2007). Resiliency in adolescent college students. *Electronic Theses and Dissertations.* https://stars.library.ucf.edu/etd/3049

Ang, M.C., & Diaz, L.B. (n.d.). Perception, resiliency and coping strategies of Filipinos amidst disasters. [Unpublished manuscript]. Bulacan State University.

Bonner, C.F. (2015). Moderating effects of coping self-efficacy and coping diversity in the stress health relationship in African American college students. *ODU Digital Commons.* https://digitalcommons.odu.edu/cgi/viewcontent.cgi?article=1250&context=psychology_etds.

Bozkurt, A., Jung, I., Xiao, J., Vladimirschi, V., Schuwer, R., Egorov, G., ... & Paskevicius, M. (2020). A global outlook to the interruption of education due to COVID-19 pandemic: Navigating in a time of uncertainty and crisis. *Asian Journal of Distance Education, 15*(1), 1-126.

Chen, C. (2016). The role of resilience and coping styles in subjective well-being among Chinese university students. https://doi.org/10.1007/s40299-016-0274-5.

Cao, W., Fang, Z., Hou, G., Han, M., Xu, X., Dong, J., & Zheng, J. (2020). The psychological impact of the COVID-19 epidemic on college students in China. https://doi.org/10.1016/j.psychres.2020.112934

De Guzman, D. (2012). Selected factors, study habits, and academic achievement: Towards a proposed guidance training design. [Unpublished manuscript].

Delvecchio, E., Orgilés, M., Morales, A., Espada, J. P., Francisco, R., Pedro, M., Mazzeschi, C. (2022). COVID-19: Psychological symptoms and coping strategies in preschoolers, schoolchildren, and adolescents. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8786599/.

Di Pietro, G., Biagi, F., Dinis Mota Da Costa, P., Karpinski, Z., & Mazza, J. (2020). The likely impact of COVID-19 on education: Reflections based on the existing literature and recent international datasets. https://publications.jrc.ec.europa.eu/repository/handle/JRC121071.

Fluharty, M., Bu, F., Steptoe, A., & Fancourt, D. (2021). Coping strategies and mental health trajectories during the first 21 weeks of COVID-19 lockdown in the United Kingdom. https://pubmed.ncbi.nlm.nih.gov/33965772/.

García, F. E, Barraza-Peña, C. G, Wlodarczyk, A., Alvear-Carrasco, M., & Reyes-Reyes, A. (2018). Psychometric properties of the Brief-COPE for the evaluation of coping strategies in the Chilean population. https://pubmed.ncbi.nlm.nih.gov/32026069/.

Ignacio, L. (2011). Ginhawa: Well being in the aftermath of disasters. Philippine Psychiatrists Association, Inc. https://docs.google.com/file/d/0BzFebEZpWV-wemR5NWZCaG1jeEU/edit?resourcekey=0-vOiRGXe2pBCd5rAHrXxwcQ.

Lappe, J. M. (2000). Taking the mystery out of research: Descriptive correlational design. *Orthopedic Nursing, 19*(2). http://hd/.handle.net/10504/72007.

Malkoc, A., & Yalcin, I. (2015). Relationships among resiliene, social support, coping and psychological well-being among university students. *Turkish Psychological Counseling and Guidance Journal, 5*(43), 35-43.

Markova, S., & Nikitskaya, E. (2017) Coping strategies of adolescents with deviant behaviour, *International Journal of Adolescence and Youth, 22*(1), 36-46. DOI: 10.1080/02673843.2013.868363

Murphey, D., Barry, M., & Vaughn, B. (2013). Positive mental health: Resilience. https://www.childtrends.org/

Nicomedes, C. J. C., & Avila, R. M. A. (2020, July 15). An analysis on the panic during COVID-19 pandemic through an online form. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7362858/.

Orgilés, M., Espada, J.P., & Morales, A. (2021). How super skills for life may help children to cope with the covid-19: Psychological impact and coping styles after the program. *Revista de Psicología Clínica con Niños y Adolescentes, 7*(3), 88-93. https://doi.org/10.21134/rpcna.2020.mon.2048:contentReference[oaicite:0]{index=0}:contentReference[oaicite:1]{index=1}.

Psychology Today. (2022). Adolescence. https://www.psychologytoday.com/us/basics/adolescence.

Rutter, M. (2006). Implications of resilience concepts for scientific understanding. *Annals of the New York Academy of Sciences*.

Salkind, N.J. (2010). *Encyclopedia of research design* (Vols. 1-0). SAGE Publication.

Seiffge-Krenke, I. (2000). Causal links between stressful events, coping style, and adolescent symptomatology. *Journal of Adolescence, 23*, 675–691

Seligman, M. (1998). *Learned Optimism*. Pocket Books.

Valladolid, V. C. (2021). The role of coping strategies in the resilience and well-being of college students during covid-19 pandemic. *Philippine Social Science Journal, 4*(2), 30–42. https://doi.org/10.52006/main.v4i2.342

Zimmer-Gembeck, M. J., & Skinner, E. A. (2011). Review: The development of coping across childhood and adolescence: An integrative review and critique of research. *International Journal of Behavioral Development, 35*(1), 1–17. https://doi.org/10.1177/0165025410384923.

Examining a Youth-led Participatory Video Process in Disaster Risk Reduction Management in a Philippine Rurban Community

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Abstract

This paper explores what constitutes a youth-led participatory video (PV) process in disaster risk reduction management (DRRM) in a flood-prone community in Bay, Laguna, Philippines. It also aims to discuss the youth's concepts of DRRM and PV. A PV training workshop was conducted from January to March 2019, along with qualitative interviews, focus group discussions, and participant observation. Youth's concepts of DRRM primarily centered on disaster preparedness through information dissemination and capacity building. They appreciated the PV process because they were able to learn new knowledge and skills in PV production and DRRM and produce an advocacy video on typhoon preparedness. The generated grounded theory is that a youth-led PV process is a learning and capacity-building process that enables adults and youth to realize the latter's capacity and shared responsibility to participate in DRRM initiatives. It serves as an entry point and strategy in community organizing. Through a PV process, participants build their capacities, co-construct knowledge, develop critical awareness, and take action to improve their situation. Beyond empowerment, PV is a development communication tool that helps participants realize their capabilities to become partners in development and live meaningful lives.

Keywords: disaster risk reduction management, grounded theory, participatory video, development communication, youth participation

Introduction

This paper draws on the experiences of a group of youth in Bay, Laguna, Philippines, who conducted a participatory video (PV) project in the context of disaster risk reduction management (DRRM). As part of a broader study, this paper examines the factors that define the Participatory

Video (PV) process, particularly in the context of Disaster Risk Reduction and Management (DRRM) led by youth. It explores the youth participants' understanding of PV and DRRM while proposing a theoretical framework for a youth-driven PV process. A separate paper focuses on community development (Mendoza & Flor, 2024), and both papers have the same theoretical groundings and methodology. This study focused on one case of selected youth participants within a given context. It does not aim to uncover one singular authentic voice or truth of how youth lead a PV process and respects the diversity of people's experiences doing PV.

Participatory Video

A PV approach, first known as the Fogo process, is believed to be a model of communication for development practice ahead of its time and a participatory development communication methodology. Donald Snowden, an important pioneer in participatory video (PV) in the field of communication for development, helped catalyze the use of this approach. In the late 1960s, researchers documented the Fogo Process to facilitate dialogue between fisherfolk residents of Fogo Island, Canada, and government officials, as the residents voiced their concerns about being resettled to the mountains (Haynes & Tanner, 2015; Ferreira, n.d.)

Since then, PV has been used as a tool for facilitating discussion and information-sharing among marginal communities (High, Singh, Petheram, & Nemes, 2010; White, 2003), for learning (Snowden, 1984; as cited in FAO, n.d.), for individual, group, and community development where people can freely share their ideas without any barriers, and for self-definition and empowerment, and education and training (White, 2003).

Although PV has been practiced and studied for decades now, there is little shared understanding of what PV is, what it does, and how it does it (Yang, 2016). In addition, there are no clear definitions of what constitutes PV (White, 2003).

Moreover, there are limited studies on the PV methodology and less developed links to research (High, 2010), a lack of well-formulated theories or solid theoretical foundations that can provide a basis for PV practices (White, 2003), and few theoretical frameworks of PV in development (Plush, 2013). Participation is rarely defined explicitly in PV studies despite being highly debatable (Low et al., 2012).

These knowledge gaps in PV prompted this study, which explores what constitutes a PV process, particularly a youth-led PV process in DRRM.

Disaster Risk Reduction Management in the Philippines

DRRM is described by the United Nations Office for Disaster Risk Reduction (UNISDR) (n.d.) as "the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses." DRRM is often used interchangeably with DRR, although UNISDR (2015, as cited in PreventionWeb, 2015) differentiates DRRM as more of the implementation of DRR because it describes the actions needed to reduce risks. These systematic DRR efforts include improving preparedness and early warning systems, wise land and environment management, and decreasing the vulnerability of people and property (UNISDR, n.d.).

The Philippines is committed to the Sendai Framework for Disaster Risk Reduction 2015-2030 and actively participated in its development. With innovations developed through consultations, the Sendai Framework aims to continue guiding countries, communities, and other actors in managing and preventing new risks (Department of Foreign Affairs [DFA], n.d.).

The Philippines has implemented several laws and policies supporting DRRM. In July 2009, lawmakers developed Republic Act No. 10121, the Philippine Disaster Risk Reduction and Management Act of 2010. This law aimed to strengthen the country's DRRM system and institutionalize the National DRRM Plan and National Disaster Coordinating Council (later renamed the National DRRM Council or NDRRMC) (NDRRMC, n.d.). The Council's role is to protect the welfare of the people during disasters or emergencies. Currently, the country implements the National DRRM Plan, which serves as a national guide "on how sustainable development can be achieved through inclusive growth while building the adaptive capacities of communities, increasing the resilience of vulnerable sectors, and optimizing disaster mitigation opportunities with the end given promoting people's welfare and security towards gender-responsive and rights-based sustainable development" (Department of the Interior and Local Government, n.d., p. 5).

Child and Youth Participation in Disaster Risk Reduction Management

According to the UN (2013), for statistical purposes, youth is defined as persons aged between 15 and 24. As a category, however, youth is more fluid than other fixed-age groups because it is a transition period from childhood dependence to adult independence. Furthermore, the experiences

of young people worldwide vary, and therefore, the definition is not universal. Providing context is an important guide in UNESCO's definition of youth (UNESCO, n.d.). The Youth in Nation Building Act (Republic Act 8044) defines youth in the Philippines as a crucial stage in a person's growth and development, beginning at the onset of adolescence at 15 years old and continuing until the individual reaches the age of 30, when they become a mature, self-reliant, and responsible adult (Quilloy, 2016).

Youth participation has been studied and defined by several scholars and organizations since the 1970s (Hart, 1992; Shier, 2001; Treseder, 1997; as cited in Wong, Zimmerman, and Parker, 2010; Wong, Zimmerman, & Parker, 2010; & Kirby, Lanyon, Cronin, & Sinclair; 2003). In 1975, it was defined by the US National Commission on Resources for Youth as "the involving of youth in responsible, challenging action that meets genuine needs, with opportunities for planning and/or decision-making affecting others in an activity whose impact or consequence is extended to others—i.e., outside or beyond the youth participants themselves." The organization Save the Children described youth's responsibilities in participation in 2000 as "sharing ideas, thinking for themselves, expressing their views effectively, planning, prioritizing and being involved in the decision-making process" (Mitchell, Tanner, & Haynes; 2009, p. 8).

Beliefs that adults are more aware of their families' and communities' needs and thus more capable of protecting short- and long-term interests primarily dominate DRRM. Thus, mainstream disaster management approaches have failed to involve children and young children as possible communicators of risk and facilitators of DRRM (Mitchell & Tanner, 2009). However, research studies show that children and youth play an important role in DRRM (Mitchell & Tanner, 2009; Back, Cameron, & Tanner, 2009; Tanner, 2010; Haynes & Tanner, 2013; Plush, 2012).

Only a few studies have been published on youth-led PV in DRRM and climate change (Plush, 2012; Haynes & Tanner, 2015). These studies aimed to evaluate the effectiveness of PV as a tool for empowering young people to raise awareness of climate change and DRRM and promote social change. An ActionAid Nepal program found that Participatory Video (PV) could empower children in Nepal to understand, confirm, and amplify their concerns about climate change (Plush, 2009). Moreover, a youth-led PV study in Eastern Samar, Philippines, in partnership with the NGO Plan International, showed that using PV can empower the youth to raise climate change and DRR issues and advocate change (Haynes & Tanner, 2015).

A similar community-based participatory approach called PhotoVoice was conducted in Hawaii and was found to assist a vulnerable

community in developing localized disaster reduction strategies through dialogue. The process increased the community's awareness, capacity, and engagement toward disaster preparedness (Crabtree & Braun, 2015).

Theoretical Grounding

Concepts and frameworks in participatory action research (PAR), community organizing, and learning alliance (LA) were used as lenses in theorizing a youth-led PV process in DRRM.

Participatory Action Research

Discussions on PAR begin with understanding the implicit relationships between power and knowledge. In the first dimension of power, individuals or groups mobilize knowledge or research as resources to influence public debates. Power is a product of conflict between actors. Knowledge is, therefore, a resource that can be used and mobilized to influence policy. In this first view of power and knowledge, issues on who produces knowledge and the impact of this knowledge on those who are marginalized are not prioritized (Gaventa & Cornwall, 2001).

In the second dimension of power, the powerful aims to set the public agenda by keeping other actors from participating in the knowledge production process. This is where the conflict between experts and laypeople is emphasized. Thus, scientific rules are used to dictate the validity of the knowledge of some groups over others. Action research thus became a tool to mobilize the marginalized to act and participate in public affairs. The relatively powerless become empowered as they become involved in knowledge production (Gaventa & Cornwall, 2001).

However, the second-dimensional view of power still maintained the idea that the exercise of power includes conflict between the powerful and the powerless. In the third dimension, Steven Lukes (as cited in Gaventa & Cornwall, 2001) argues that the most effective use of power is to prevent conflict from even happening. Instead, the control of knowledge and how it is produced shapes the consciousness of the public agenda. Participation in knowledge production allows the powerless to become more aware of their issues and capacities for action. Many scholars and researchers in participatory research have advocated this belief (Gaventa & Cornwall, 2001).

Community Organizing

Community organizing is the primary method in community development, which engages people to work together towards common goals and development. Without community organizing, one cannot engage in developing communities (Luna, 2009). Processes or approaches in community organizing may overlap or be repeated at new levels; these include integrating with the community, social investigation, identifying problems or issues, doing groundwork, meeting, role-playing, mobilizing, evaluating, reflecting, and establishing the organization (TWSC, 1990; as cited in Luna, 2009).

Three areas of community organizing are proposed by the Community Development Framework: area-based organizing, sectoral or issue-based organizing, and building networks, alliances, and coalitions. Area-based organizing is done within a geographic space, such as villages or groups of adjacent communities. Sectoral or issue-based organizing is done among sectors (e.g., fisherfolk, farmers, women) that experience common issues, problems, or enemies. These two areas of organizing can overlap, and community members can be organized through area-based or issue-based organizing. Both types of people's organizations can work together to build networks, alliances, or coalitions with horizontal relationships. On the other hand, networks, alliances, and coalitions (also called supra-organizations) are created when people participate in decision-making and collective action. They serve as tools to help people express their opinions and create changes in the community (TWSC, 1990; as cited in Luna, 2009).

Learning Alliance and Social Learning

The LA approach is a process that has been used in research and development projects, which involves "identifying, sharing, and adapting good practices in research and development in specific contexts" (Lundy et al., 2005, p.1). It draws heavily from action research, social learning, and the scaling up of innovations (Moriarty, Fonseca, Smits, & Schouten, 2005). These good practices discussed in LAs can strengthen capacities, identify future needs or areas for collaboration, and inform public policy decisions. What is crucial and challenging in an LA approach is identifying relevant good practices, adapting them to the existing needs and conditions of the community, applying them more widely, and documenting and sharing the outcomes (Lundy et al., 2005).

The key components of an LA are a range of linked stakeholders'

creation of new knowledge in an area of common interest. Furthermore, an LA approach requires facilitation to break barriers between stakeholders and sustain their interest in the initiative. Facilitation also helps overcome horizontal and vertical obstacles in information sharing and thus enables a shared learning process. Learning alliances aim to include all relevant stakeholders in a knowledge production process to ensure that the knowledge created is appropriate, sustainable, and scalable (Moriarty et al., 2005).

Development Communication for Social Justice

The theoretical models of development communication after WWII (during the modernization paradigm) used a behavior change communication model based on positivist philosophy and methodology and believed that media and information could educate the masses and bring about change. The participatory model of development began in the 1970s and advocated for a widely participatory process of social change in society, which included methodologies such as participatory rural appraisal and PAR. While the participatory models brought new insights to the field, the definitions of participation varied, and in many cases, people's participation was low and obligatory. During the end of the 1980s, the concept and practice of empowerment expanded the objectives of the participatory development communication models and ushered in the second major interdisciplinary thrust in development communication research and practice (Melkote, 2018).

In the empowerment paradigm, development communication sees the people's lack of power as beneficiaries of development programs and aims to empower these people and build local capacity and equity. Development communication activities began to include activating and sustaining social support systems, empowering local narratives, and facilitating critical awareness and community power. Moreover, scholars now recognize the value of communication in organizing (Melkote, 2018).

In 2015, Melkote and Steeves proposed a conceptual framework for development communication for social justice in directed change. Their framework describes development communication's roles in addressing and fighting injustice and inequality in directed change. These roles include "emancipatory political and social action (as evidenced by freedom from underdevelopment, inequality, and servitude), and the politics of self-actualization or life politics (described as freedom to explore one's individual/group potential and live an effective and meaningful life as an expressive human being)" (Melkote & Steeves, 2015, p. 455).

Grounded Theory

Developed in the mid-1960s by psychologist Barney Glaser and sociologist Anselm Strauss, grounded theory aims to construct substantive and formal theories. The approach focuses on investigating people's everyday lives, interactions, behaviors, and the construction of reality, which are further reshaped by the researcher's frames of reference (Grbich, 2013). Furthermore, Grbich (2013) said that the grounded theory approach is best used for small-scale environments and micro activity where little research has been done.

Charmaz (2011, p. 360) defined grounded theory as "a method of qualitative inquiry in which data collection and analysis reciprocally inform and shape each other through an emergent iterative process." Grounded theory is both a method and a product (i.e., a social scientific theory developed from successive conceptual data analysis). It begins with a systematic inductive approach to inquiry, where findings are subjected to tentative categories and rigorous tests (Charmaz, 2011).

Methodology

As mentioned earlier, this methodology was used in the paper examining PV as a capacity-building strategy in DRRM of this study (Mendoza & Flor, 2024) and is briefly discussed here.

Informed Consent

Permission to conduct the study was obtained from the municipal mayor of Bay and chairs of Barangay (Brgy.) San Antonio and Sangguniang Kabataan (SK). Since it was a participatory video process, the purpose of the research was explained to participants before commencing, that their participation was voluntary, and they could withdraw at any point in the study. Informed consent was obtained from each participant after thoroughly explaining the study. Confidentiality was also agreed between the researchers and the participants. Any identifiable data, save for those who consented to publish them, have been removed.

PV Training Workshop

A PV training workshop in the context of DRRM was conducted from January to March 2019 in Brgy. San Antonio, Bay, Laguna, a Philippine

rurban community. The training workshop comprised seven sessions: introductory meeting and storyboarding, DRRM training workshop, PV production workshop, actual video shoot, hands-on video-editing workshop, reflection activity, and PV viewing and planning. The PV researcher facilitated the PV workshop sessions while staff from the municipal disaster risk reduction management office (MDRRMO) provided the DRRM lectures.

Thirteen youth participants aged 12 to 22 regularly participated in the study. Eight were female, while five were male, with educational levels ranging from grade 6 to 3rd-year college. The participants were members of the SK, Brgy. Little Officials, Brgy. Children's Association, and regular residents. Key officials in charge of DRRM, such as the MDRRMO head of Bay, the barangay captain, and three barangay councilors responsible for DRRM in the barangay, were also interviewed.

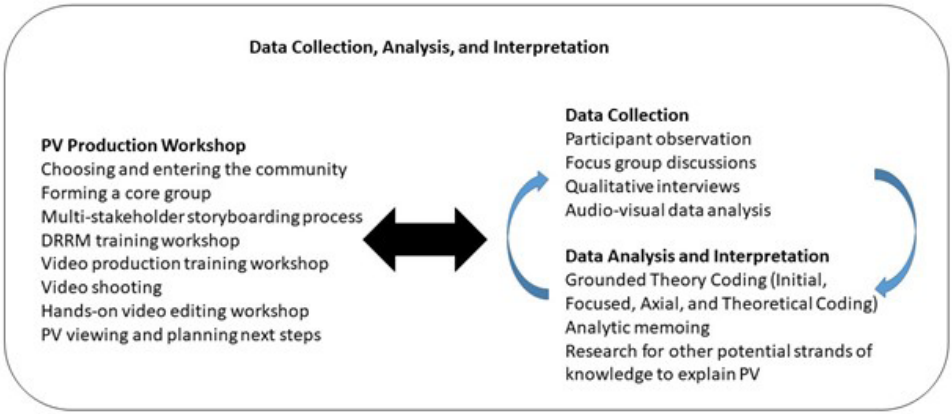
Charmaz's (2008) constructivist grounded theory method guided data collection and analysis. Analytic memoing and grounded theory methods of qualitative coding (Initial, Focused, Axial, and Theoretical Coding) (Saldaña, 2016) were used to analyze and interpret data. Analytical memoing was applied during coding as an analytic procedure to explain coded categories using grounded theory methodology (Schwandt, 2015).

Transcripts of the participants' in-depth interviews, observation field notes, observation notes on audiovisual data (i.e., videos produced by participants), and the primary researcher's field notes were coded (Mendoza & Flor, 2024). Two cycles of coding were applied, following Saldaña's (2016) recommended methodology for grounded theory studies. In Vivo and Process coding, foundation methods for grounded theory were used for the first or initial cycle. A second cycle of coding was done as part of grounded theory work to explore the intricacy of data. In particular, Focused Coding, Axial Coding, and Theoretical Coding were applied as these are the latter stages of developing grounded theory (Saldaña, 2016).

Figure 1 indicates the methodology used in gathering and analyzing the data from the study (Mendoza & Flor, 2024).

Figure 1

Process Flow in Data Gathering and Analysis of PV Study Data



From: Mendoza and Flor (2024)

Research Site

Due to its proximity to Laguna Lake, the municipality of Bay is prone to flooding. Moreover, many areas of Bay fall within the watersheds of Mt. Makiling Forest Reserve. Several creeks and rivers cross the center of the Bay, such as the Bay River running along San Nicolas and San Agustin and the Calo River intersecting Barangays Maitim and Calo. These water bodies cause floods in several barangays, such as Maitim, Tagumpay, San Antonio, and Sto. Domingo during heavy rainfall and typhoons, bringing about physical and socio-economic impacts (Sarmiento et al., 2020; Municipality of Bay, 2022).

Brgy. San Antonio is the largest barangay in the town of Bay, with a total land area of 138.72 hectares and 6,280 residents as of 2012 (Quilloy, 2016). Since 1972, typhoons Ondoy and Habagat caused the most impact of all the disasters experienced by the barangay, with floods bringing difficulties in transportation, livelihood, and school activities that lasted for almost four months in the barangay.

Results And Discussion

Participants' Concepts of DRRM

The youth's concepts of DRRM do not strictly follow the Philippine NDRRMC definition of DRRM as "a systematic process of using administrative directives and organizations to implement policies and

improved coping mechanisms to lessen adverse impacts of hazards." Instead, they view DRRM primarily as 1) 'paghahanda' (disaster preparedness) through proper information dissemination (e.g., typhoon warnings) and 2) capacity building (e.g., earthquake drills, fire prevention drills, etc.). Furthermore, the resulting codes that reflected the youth's recognition of a lack of timely warnings and DRRM training workshops matched their decision to produce a PV advocating typhoon preparedness.

After completing the PV workshop, they believed they could share their knowledge of DRRM with their classmates, siblings, relatives, families, and even adults. They mostly see their current role in DRRM as teachers and sharers of information. Their primary reasons for wanting to participate in DRRM initiatives are 1) to learn further, 2) to help those affected by disasters, 3) to share their knowledge and skills, and 4) to inspire others to participate.

In contrast, the barangay officials of San Antonio have a broader, more holistic view of DRRM, which reflects the official definitions of NDRRMC. Moreover, the concepts of adult barangay officials of DRRM are more community-based and tailor-fit to their conditions. These include 1) standard activities and protocol promoted in DRRM; 2) the community's strategies and belief systems in implementing DRRM, including each individual's values of service, commitment, and sacrifice; and 3) barangay officials' beliefs and views on their authority and power in making decisions and conducting activities for the community.

In hindsight, it can be expected that adult barangay officials will have a more holistic view of DRRM and be more knowledgeable of its different facets than the youth. The barangay officials have undergone more training and capacity building in DRRM and have addressed DRRM issues in the community more than the youth. Most youth participants found the PV training workshop to be their first experience attending workshops outside of school. However, from their general notions of DRRM as disaster preparedness and prevention, it can be deduced that the youth already have a good background in DRRM to build on.

Four out of the five officials saw the importance and responsibility of the youth of Brgy. San Antonio to participate in DRRM initiatives. They believed that if trained correctly in DRRM, youth members would contribute significantly and ease their responsibilities in DRRM. The tasks they saw fit for the youth participants included sharing information, evacuating flood victims, cleaning up, encoding data, and distributing relief goods. They emphasized that while they welcome the youth's participation in DRRM, the youth should be given only age-appropriate roles and proper DRRM

training.

Participants' Concepts of the PV Process

Data analysis revealed that adult officials and youth participants believe in the youth's capacity to participate in community initiatives such as DRRM. Both expressed their commitment to support the study as a DRRM project for the youth of Brgy. San Antonio, reinforcing their positive notions of the youth's capacity in DRRM. Furthermore, in conducting a youth-led PV process, assessing DRRM problems is not done separately but is part of storyboarding, a first step in PV production. Lastly, being a participatory process with youth as participants, it is important to know their strengths, weaknesses, and personalities. Their characteristics can affect their capacity to develop their skills, knowledge, and talents. Furthermore, a PV process with youth participants means that the PV facilitator needs to adjust activities, schedules, teaching styles, and other aspects to be more appropriate for the youth. These different categories reflect the various facets of the PV experience of the youth participants based on the interpretation of the data gathered.

Furthermore, all participants were pleased with the PV process and their final video. They expressed joy in completing the process and task at hand and sadness that the PV project was over. They were happy to have learned many things in both DRRM and PV production, highlighting the preparation of the go-bag and video editing as two new main lessons learned. In individual interviews, participants highlighted the teamwork and bonds they formed during the PV process. The final PV included all the video testimonials of the participants, and no one was left out. Participants gained knowledge and skills in both DRRM and video production, and younger participants also contributed significantly and kept up with the older participants. Furthermore, they were glad to have invested time participating and considered it a wise decision. The SK chair also liked the PV process and said that the final video could serve as an advocacy video created by the group to inspire other youth and community members to participate and become more prepared for typhoons.

Resulting Themes of a Youth-Led PV Process in DRRM

Based on the results of coding data, the themes that make up or constitute a youth-led PV process in DRRM emerged. These are participation, learning and capacity building, advocacy, empowerment, and emancipation.

Participation

Participation in a youth-led PV process in DRRM is fluid and fluctuating. Participants' contributions come in different forms. The younger participants were not as vocal in expressing their insights and opinions during discussions, perhaps due to a lack of confidence and knowledge on the subject, but they attended all workshop sessions and participated in completing the PV.

In contrast, older participants (college students) missed a few sessions, but they contributed in other forms (e.g., facilitating the storyboarding, suggesting the PV topic, and editing the final PV), and their opinions helped make decisions for the group. In their case, participation was output-based and not dependent on how long or how often they attended the activities.

Thus, one cannot assume one form of participation to be better than the other. Both forms of participation contributed to the completion of the PV process. Furthermore, their participation in PV production also provided them with different learnings that will empower them as they grow older, providing them with opportunities to improve themselves further.

Youth participation in conducting a PV process in the context of DRRM does not follow the traditional hierarchical views of Hart's 1992 ladder of young people's participation and Shier's 2001 pathways to participation (as cited in Wong, Zimmermann, & Parker, 2010) that youth-driven participation is ideal. Instead, youth and adults working on DRRM need shared control in planning and decision-making. While the youth can take on specific tasks and roles in DRRM, such as information sharing, packing and distributing relief goods, and others, they should also not be given burdensome and dangerous tasks beyond their capacity. This research reflects the typology of youth participation and empowerment of Wong, Zimmerman, and Parker (2010), where youth and adults have shared control. DRRM roles for the youth must be age-appropriate, and they must undergo proper training before they are considered ready to serve the community.

Furthermore, younger participants view the PV process mainly as an avenue to learn new skills and develop their abilities, especially since capacity-building opportunities for the youth are not always common in many Philippine rurban communities. Therefore, pluralistic participation is important, as PV facilitators are observant in identifying which areas they should take the lead in and when they should give control to participants.

PV facilitators should teach participants the most appropriate PV methods possible. In areas or stages where participants need guidance, PV facilitators should be ready to help them make smart decisions. When

participants exhibit confidence in their capabilities, PV facilitators should know when to step back and give them control. Therefore, participation in a youth-led PV process cannot always be about giving full control to the participants (for the sake of being participatory) because they still need guidance in making decisions. Allowing them full control of the process can lead to missed targets, waste of resources, incompletion of the PV, and even conflicts within the community.

Learning and capacity building. The PV process is a platform for learning and capacity building. In a PV form that aims for participants to have more control in decision-making and implementing the process, they are taught PV production skills from storyboarding to video shooting and editing through a series of workshops. Since the participatory aspect is emphasized, participants learn to discuss, plan, and work together.

Besides learning about PV production, participants also enhance their capacities in technical topics such as DRRM. These new knowledge and skills in both technical topics (e.g., DRRM) and PV production boost the confidence of participants' confidence that they can apply these skills and share them with others. Engaging in PV production allows participants to showcase and hone their other innate talents, knowledge, and skills.

The learning and capacity-building component of the PV process is vital among youth participants in a Philippine rurban community. In Brgy. San Antonio, capacity-building activities are not regularly provided for the youth. As the SK chair shared, capacity-building workshops for the youth in their area create a difference in their lives at both cognitive and affective levels. Thus, it can inspire youth to become future community leaders.

Furthermore, in a PV process, participants learn from one another and co-construct knowledge. As they engage in dialogue and brainstorm, new forms of knowledge are created. Their narratives and experiences in the community can affect or alter the original knowledge that was first taught or introduced during the PV workshops. They can modify PV production techniques and practices to suit their needs and situations in the community.

More importantly, the knowledge they co-create is not simply produced for knowledge's sake. Instead, these new knowledge and skills empower participants to become more critical of their situations, needs, concerns, and issues in the community. As they build their capacity, they become more confident in themselves and their capabilities to create change in their community.

Advocacy

The PV process is a tool for advocacy that aims not only toward policy and decision-makers but also to create change among community members. It can present alternative ways of living through videos on success stories and best practices.

A unique feature that sets the PV process apart from other processes is its ability to tell stories or narratives of the community through video. This holds true not only for a youth-led PV process but also for all forms of PV with participants of different ages. Through video, community members support a cause or proposal and air their views on an essential topic in the community. This study includes advocacy as a theme of the PV process, similar to the theoretical frameworks on PV developed by Plush (2013) and Sitter (2012).

Community members can discuss their community's most pressing issues and concerns. Since a PV process usually takes several days or weeks to complete, participants have more time to understand the complexities and consequences of an issue clearly. They can reflect upon the issues as they conduct the PV process, finalize their storyboard, and shoot and edit their video footage.

Participants also go beyond learning about these issues and think of ways to present them to other community members. Their new knowledge and skills in video production, such as camera movements, shots, angles, voice narration, and video editing, help them present the issue more clearly and creatively.

Walsh (2014) critiqued that a problematic aspect of PV is that it is used to capture the stories of the marginalized and voiceless to be shown to higher officials decision- and policymakers. He argued that PV should go beyond merely aiming to voice concerns to those in power to reflecting, imagining, and constructing other ways of living in our world (Walsh, 2014).

This study's PV process supports Walsh's (2014) observations. The PV created by the youth participants was not mainly aimed at the community leaders, which is often the case for many PV projects. Instead, their PV was created primarily for the community to urge residents to become more responsible and prepare well for future typhoons. Out of 100, Brgy. San Antonio youth, 37% did not prepare before a typhoon, and 26% prepared a week before a typhoon (Quilloy, 2016).

Their produced PV, therefore, promotes several effective strategies to prepare for a typhoon (recommended by the MDRRMO). It aimed to change the usual practice of the residents who usually do not prepare ahead

and "construct other ways of living," as Walsh (2014) recommended.

The PV process allowed the participants to reflect and imagine how they could participate more in the community. It made them realize they could become part of a core team engaged in DRRM. It helped them consider themselves possible teachers of DRRM and PV production. This PV process, therefore, took on a different direction and went beyond merely presenting their views to authorities and leaders, but instead allowed them to reflect, imagine, and construct an alternative way of living. Furthermore, participants realize they have a significant role in the community. As they engage in dialogue and learn from one another, they discover that even as young community members, they can assume specific responsibilities in DRRM matters. The process allows them to reflect and analyze what specific DRRM roles they can assume.

Moreover, participants, especially young people, become critical when participating in a PV process. If, in the past, they were only confined to staying at home or attending school, their perspective on matters that concern their community is widened due to the PV process. They learn to reflect and analyze which issues are most important and which need to be communicated or discussed through a PV.

They also feel competent in their capabilities as they accomplish tasks needed to complete a PV. The PV project participants felt proud of themselves for completing the PV process and became confident about sharing information about what they had learned.

The PV process can also serve as a catalyst for future community leaders. Realizing that they can accomplish tasks and make decisions independently, youth participants can be inspired to assume more responsibility through the PV process. The PV facilitator can help participants overcome their feelings of insecurity and meekness by providing encouragement and learning opportunities.

In addition, participants who have undergone a PV process also become empowered as a group. A PV process can act as an entry point to community organizing and establish a core group of community members willing to participate. As they interact with one another during the PV process, participants often form a bond. They appreciate and highlight one's strengths and learn to accept and compensate for another's weaknesses. If PV participants can experience and accomplish a successful PV process and form strong bonds of friendship and camaraderie, they will most likely continue working together on future community projects.

Emancipation

Beyond being an empowering process, PV production triggers an emancipatory process where participants can work towards freedom from inequality and freedom to improve themselves.

The participants' added knowledge and skills on DRRM and PV production allow them to assume bigger responsibilities and play more important and influential roles in the community. PV participants can realize that they are not mere beneficiaries of community development programs but can become active participants, actors, and partners in development.

Furthermore, the PV process can liberate participants from insecurity, inexperience, lack of knowledge and skills, and lack of authority. Instead, it enables them to see themselves as future agents of change in the community. In the same way, adults' preconceived notions of youth as helpless, indifferent, unknowledgeable, or as possible liabilities during disasters can be removed, and they can acknowledge that the youth can participate in DRRM.

The PV process also initiates a process where participants can be free to explore their potential individually or as a group to live meaningful and expressive lives. In this study, the participants realized they wanted to have a voice and be involved in community affairs. As a group, they expressed commitment to participate should a DRRM core team be officially established. Individually, they were confident they could apply their skills in PV and DRRM and share them with others. The PV process made them recognize their abilities to improve themselves and become more involved in community matters.

Beyond empowerment, the PV process triggers an emancipatory process where participants can achieve freedom from inequality and explore their capacities to live meaningful lives. The PV process is a development communication tool for social justice that can be used for advocacy communication, networking, empowerment-related communication, and community mobilization.

The grounded theory generated by this study is that a PV process is a learning and capacity-building process that enables youth and adult community members to realize the latter's capacity and responsibility to participate in DRRM. It can also serve as an entry point and strategy in community organizing. It provides a learning platform for various stakeholders to determine their problems, build capacity to address them, reflect on the process, and plan the next steps. It helps participants co-create knowledge, become more critical of their situation, and try to effect change

and challenge the dominant class. Furthermore, it triggers an emancipatory process where participants can be freed from inequality and live meaningful lives.

Theoretical Framework of a Youth-Led PV Process in DRRM

A theoretical framework for a youth-led PV process in DRRM was created by analyzing the phenomenon from PAR, the learning alliance approach, and community organizing concepts, and Melkote and Steeves' (2015) conceptual framework on development communication for social justice.

PV as an Entry Point and Strategy in Community Organizing

The PV process can serve as an entry point and strategy in community organizing. It can serve as a strategy to organize and capacitate youth members to become involved in matters concerning their community. Since video is a powerful visual medium widely used and appreciated worldwide, more people are likely to participate in community workshops if video production skills are to be taught. Learning video production skills is even more appealing to youth participants because of their interest in videos and video making. Video has become a prevalent form of communication tool, and with smartphones and social media, it has become easier to produce, share, and access videos nowadays.

As participants go through the PV process, they follow steps similar to the method of community organizing: they examine and identify critical issues to be addressed; they build their capacity and learn to become more critical and self-aware; they plan and take action; and reflect and plan their next steps.

Establishing a group of PV participants follows the main methods of community organizing, according to Luna (2009). PV participants can be grouped according to issue or sector (e.g., farmers, youth, fisherfolk, senior citizens), or they can be grouped according to where they reside (i.e., area-based).

A youth-led PV process is particularly unique because of its participants. Since youth participants are usually more receptive and pliable to ideas than adults (especially this study's participants, who are aged from 12 to 22), the PV process can serve as a way to develop character and instill values. Some participants in this research overcame their shyness and became more confident about themselves and their capabilities after

undergoing the PV process. Strategies can be injected into the PV process to aid in developing youth's personalities and inspiring leadership.

Moreover, youth participants with the potential to become future leaders and valuable community residents can be identified as they participate in the PV process. In the study, younger participants showed their potential as leaders and expressed their interest in becoming more active in helping the community. Manalili (2012) discussed that as the community organizer immerses in the community, he/she can see who among the people has the makings of a local champion ready to act and serve others.

PV Process as a Learning Alliance

Not only is PV production a process, but it is also a platform for youth learning and capacity building in both video production and DRRM. PV's strengths as a learning and capacity-building platform lie in its ability to teach various components compared to other capacity-building activities that usually focus on limited, targeted topics.

Through the learning process, the PV process helps them realize and apply their skills, talents, and impact as a group. These inherent skills and talents (not directly related to PV or DRRM) are enriched as they practice PV production.

LA is heavily influenced by action research and social learning, which makes it very similar to PV and PAR. LA is similar to PV in that it encourages stakeholders from different institutional levels to work together towards a common goal. Both provide much emphasis on learning and capacity building, except that video is always one of the primary outputs of the PV process.

PV and LA processes also require facilitators and facilitation skills to overcome learning barriers and encourage a shared learning process. The two processes also share similar key principles. Objectives should be identified by the participants and identified at the onset of the processes. Ownership and shared responsibilities among the stakeholders/participants are emphasized. Learning mechanisms vary according to the needs, interests, and realities of the communities participating. Lastly, both processes require the facilitators or implementing agencies to build trust and rapport with the participants to work harmoniously towards devising solutions to address the prioritized issues.

The PV process also follows the stages in implementing the LA approach. Both processes begin with analyzing and identifying the needs and issues of the participants. This stage is called storyboarding in the PV

process, where the priority issue is chosen as the topic of the PV. In the LA approach, this initial stage is where the stakeholders choose their learning topics and design and adapt methods and approaches they deem necessary to apply to the good practices in the field.

In the second stage of both PV and LA processes, capacity-building activities are done with the participants. In the case of PV, this stage consists of the DRRM workshop (learning the content of the PV), PV production, and video-editing workshops (learning the PV skills).

The last stages of PV and LA involve documenting lessons learned and the reflection process. PV participants discuss their video and plan how to distribute it, as well as the next steps they need to take. Similarly, stakeholders in the Learning Agenda (LA) engage in discussions to evaluate both the successes and challenges encountered, and they outline strategies for refining and expanding the innovation on which they are focused. In this regard, both LA and PV processes can be compared with PAR, which also stresses an action-reflection cycle. LA differs from PV because it is mainly used in research and development projects to upscale innovations and good practices among stakeholders from different institutional levels. However, some PV forms, such as those done by the International Rice Research Institute, Philippines, and Digital Green, already use PV to promote agricultural best practices and technologies to both users and decision-makers. Other forms of PV practices focus more on identifying the main problems or issues of the community and how these can be addressed and presented in a video. It is in this sense that the PV process more closely resembles PAR.

PV Production as a PAR Process. This idea of becoming more self-aware and conscious of their conditions and situations through a process of knowledge production reflects a key concept in PAR. PAR is primarily influenced by Paulo Freire and other adult educators and advocates for a continuous cycle of action and reflection or conscientization, wherein people begin to become empowered as they construct knowledge. As the relatively powerless construct their knowledge, they develop consciousness and learn to act for themselves. They begin to have the ability to challenge the dominant classes (Gaventa & Cornwall, 2001).

Children and young people have often been stereotyped as potential liabilities during disasters, and they are often portrayed as victims of natural events who often need adult help (Tanner, 2010). However, during the PV project, the participants showed that they were becoming more aware of the DRRM issues they face in their community, such as the lack of timely typhoon warnings, and that community members generally did not prepare

sufficiently before typhoons. They realized this through the storyboarding process and their reflections, which were captured in their individual interviews.

Furthermore, they began to think critically about the effects of a lack of typhoon preparedness, which showed through the scenes they chose for their practice videos (i.e., comparing homes that prepared versus those that did not prepare for typhoons) and through their testimonials in the final PV of what they would do now to prepare for a typhoon.

The PV process goes through the three dimensions of PAR of Gaventa and Cornwall (2001): knowledge, action, and consciousness. Gaventa and Cornwall (2001) assert that knowledge should not be produced for knowledge's sake but instead be used to solve practical problems or improve the organization. In the PV process, the youth participants learned about PV production and DRRM to create a video on DRRM, specifically on typhoon preparedness. The participants agreed that the final PV product is an advocacy video to encourage community members to become more proactive in preparing for typhoons. They hope the video will also inspire other community youth members to participate in barangay activities. However, the transformative process does not end with the final PV product. Instead, perhaps more important is the knowledge gained in both PV and DRRM and the catalyst provided by the PV process, which has inspired the youth participants to become more involved in community affairs. The spark or catalyst injected by the PV process should then be sustained through the continuous activities of the youth participants.

The second dimension of PAR, action research, stresses that knowledge is created in iterative cycles of action-reflection-action. Youth participants underwent a first action-reflection cycle during the PV process. However, they must continue the iterative cycle to become a more transformative process where they become social actors who participate in grassroots mobilization. The SK chair has affirmed that this group of youth participants may be formally recognized as a new core group focused on Disaster Risk Reduction and Management (DRRM). Potential training workshops on DRRM are also being planned with partners from the local government and UPLB. Even if activities are not as grand (e.g., weekly clean-up drives or bible study sessions), these are important to sustain youth participants' interest and fire in learning and participating.

The third dimension PAR emphasizes is for the relatively powerless to develop critical consciousness and not merely echo the voices of the powerful (Gaventa & Cornwall, 2001). Through social learning, the relatively powerless or marginalized begin to change their understanding of their

issues, directing them to take action. Youth-led PV follows these ideas, as the older and more experienced participants shared their knowledge and opinions with the younger ones, especially at the initial stages. Over time, as they acquired new knowledge and skills, the younger participants became more sure of themselves and learned to voice their ideas. Again, it is crucial to continue the PV cycle to sustain and further develop the critical thinking abilities of the youth so that they can become social actors in the community.

PV as a Development Communication Tool for Social Justice

Beyond empowerment, the PV process triggers an emancipatory process where participants work towards freedom of inequality and freedom to explore their individual or group potential to live meaningful lives. By building their capacity in PV production and DRRM and through an action-reflection process, they free themselves from feelings of insecurity, inexperience, and lack of authority and realize they can contribute significantly to their community. They become aware that they can serve as partners in development and not just mere beneficiaries of development programs. Both adults and youth also realize that the latter can play an active role in DRRM. Adults' preconceived notions of youth as incapable, indifferent, or helpless during disasters are removed.

On the other hand, with their new skills and knowledge in DRRM and PV, the youth realize they can do more as individuals and as a group and improve themselves. Moreover, at the end of the PV process, they felt confident sharing and teaching DRRM information to others in the community. Through the PV, both adult officials and youth participants realized that the latter had the capacity and shared responsibility to become partners in DRRM initiatives. Furthermore, many participants also expressed their interest in becoming youth leaders because they wanted to make a difference and help in their community.

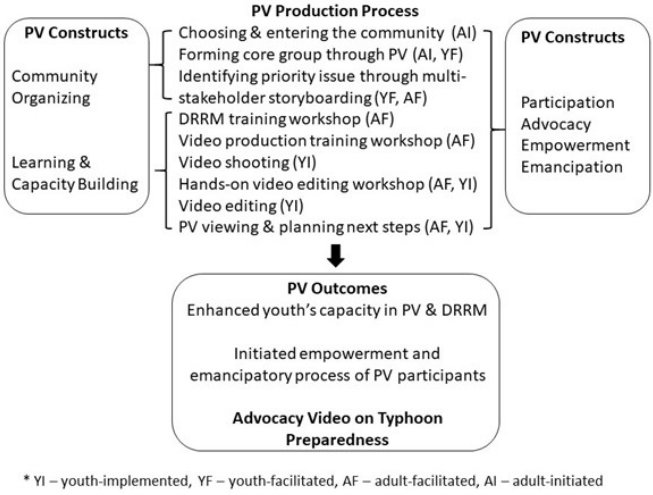
Moreover, the PV process can achieve several of the principal communicative actions prescribed by Melkote and Steeves (2015) on the roles that development communication should play to meet social justice goals. These include advocacy communication (raising awareness of issues), networking (strengthening partnerships between stakeholders), empowerment-related communication (participatory action/communication approaches, creating, expanding, and sustaining power of the community), and community mobilization (grassroots organizing and expanding and sustaining public participation).

This study proposes a youth-led PV process that consists of the PV

production process or stages, its emergent themes, and its outcomes (Figure 2).

Figure 2

Theoretical Framework of a Youth-led PV Process in DRRM



* YI – youth-implemented, YF – youth-facilitated, AF – adult-facilitated, AI – adult-initiated

Conclusion

This study's grounded theory is that a youth-led PV process enables youth and adult members to realize the latter's capacity and responsibility to participate in DRRM. It can serve as an entry point and strategy in community organizing. It provides a learning platform for various stakeholders to determine their problems, build capacity to address them, reflect on the process, and plan the next steps. It helps participants co-create knowledge, become more critical of their situation, and try to effect change and challenge the dominant class. Furthermore, it introduces an emancipatory process where participants can be freed from inequality and live meaningful lives.

Therefore, to sustain the emancipatory characteristic of the PV process, it should be implemented as an entry point and strategy in community organizing, not as a one-shot initiative. It is crucial to design and implement programs to sustain and strengthen the enthusiasm and commitment of the participants, as well as encourage other people to participate. This PV methodology can be applied to DRRM initiatives with youth participants, but it can also be adapted for other purposes (with other sectors of society) that aim to help community members address their issues

and concerns.

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References

Charmaz, K. (2008). The legacy of Anselm Strauss in constructivist grounded theory. *Studies in Symbolic Interaction, 32*, 127-141. http://dx.doi.org/10.1016/S0163-2396(08)32010-9.

Charmaz, K. (2011). Grounded theory methods in social justice research. In N.K. Denzin & Y.S. Lincoln (Eds.), *The SAGE Handbook of Qualitative Research* (4th ed.) (pp. 359-380). Sage Publications, Inc.

Crabtree, C., & Braun, K. (2015). PhotoVoice: A community-based participatory approach in developing disaster reduction strategies. *Progress in Community Health Partnerships: Research, Education, and Action, 9*(1), 31-40, 10.1353/cpr.2015.0012

Department of Foreign Affairs. (n.d.). *Philippines welcomes Sendai framework for disaster risk reduction.* https://dfa.gov.ph/newsroom/dfa-releases/5782-philippines-welcomes-sendai-framework-for-disaster-risk-reduction

Food and Agriculture Organization. (n.d.). The first mile of connectivity: Eyes see; ears hear by Donald Snowden. http://www.fao.org/docrep/x0295e/x0295e06.htm

Gaventa, J., & Cornwall, A. (2001). Power and knowledge. In P. Reason & H. Bradbury (Eds.), *Handbook of Action Research: Participative Inquiry and Practice*. (pp. 70-80). Sage Publications.

Grbich, C. (2013). Grounded theory. *In Qualitative Data Analysis, 2nd Ed.* (pp. 79-91). Sage Publication Ltd.

Haynes, K., & Tanner, T.M. (2015). Empowering young people and strengthening resilience: youth-centred participatory video as a tool for climate change adaptation and disaster risk reduction. *Children's Geographies, 13*(3), 357–371, doi: 10.1080/14733285.2013.848599.

High, C., Singh, N., Petheram, L. and Nemes, G. (2010). Defining participatory video from practice. In Milne, E-J., Mitchell, C., & de Lange, N (Eds), *Handbook of participatory video* (pp. 35–40). AltaMira Press.

Low, B., Rose, C.B., Salvio, P.M., & Palacios, L. (2010). (Re) framing the scholarship on participatory video: From celebration to critical engagement. In E-J. Milne, C. Mitchell, & N. de Lange (Eds)., *Handbook of participatory video* (pp. 49–65). AltaMira Press.

Luna, E. (2009). Community development as approach to reducing risks among flashflood-affected families in Albay, Philippines (Disaster Studies Working Paper 24). Aon Benfield UCL Hazard Research Centre.

Lundy, M., Gottret, M.V., & Ashby, J. (2005). Learning alliances: An approach for building multi-stakeholder innovation systems (ILAC Brief 8).

Manalili, A.G. (2012). Ang proseso ng pagoorganisa ng pamayanan na mula sa tao para sa tao. In *Pag-oorganisa ng Pamayanan Tungo sa Kaunlaran na Mula Tao Para sa Tao* (pp. 64-97). UP Sentro ng Wikang Filipino.

Melkote, S.R., & Steeves, H.L. (2015). *Communication for development: Theory and practice for empowerment and social justice.* (3rd ed). Sage Publications.

Mendoza, T.L.T., & Flor, B.P.G. (2024). *Participatory video as a capacity-building tool on disaster risk reduction management: The case of a Philippine rurban youth group in Bay, Laguna,* Journal of Public Affairs and Development, 10(2): 175-199.

Moriarty, P., Fonseca, C., Smits, S., & Schouten, T. (2005). Learning alliances for scaling up innovative approaches in the water and sanitation sector. IRC International Water and Sanitation Centre.

Municipality of Bay. (2022). Municipal profile: Municipality of Bay. https://bay.gov.ph/profile/

Plush, T. (2009). Amplifying children's voices on climate change: the role of participatory video. *Participatory Learning and Action* 60, pp. 119-128.

Plush, T. (2013). Fostering social change through participatory video: A conceptual framework. In P. Thomas (Ed)., *Challenges for participatory development in contemporary development practice, Development Bulletin* 2013 75 (pp. 51–54). Australian National University.

Quilloy, A.M. (2016). *Participatory action research on youth leadership for disaster risk reduction management in Bgy. San Antonio Bay, Laguna* {Unpublished MS thesis]. University of the Philippines Diliman.

Quilloy, R, M. (2016, Aug 11). Indonesian farmers and extension workers receive training on participatory video production. *Rice Today.* http://ricetoday.irri.org/indonesian-farmers-and-extension-workers-receive-training-on-participatory-video-production/

Saldaña, J. (2016). *The coding manual for qualitative researchers.* (3rd ed). Sage Publications Ltd.

Sarmiento, B., Wangdale, R., Ilagan, M. & Rasuman, K. (2020). Typhoon awareness and flood management measures: The case of Barangay Santo Domingo, Bay, Laguna, Philippines. *International Journal of Science and Management Studies,* 86-95. 10.51386/25815946/ijsms-v3i3p109.

Sitter, K. (2012). Participatory video: toward a method, advocacy and voice (MAV) framework. *Intercultural Education*, 23(6), 541–554, doi: 10.1080/14675986.2012.746842

Tanner, T. (2010). Shifting the narrative: Child-led responses to climate change and disasters in El Salvador and the Philippines. *Children & Society,* 24, 339-351. DOI:10.1111/j.1099-0860.2010.00316.x

UNESCO (n.d.). Youth: Because youth matter. https://www.unesco.org/en/youth

United Nations (January, 2013). Definition of youth: United Nations Youth. https://www.un.org/esa/socdev/documents/youth/fact-sheets/youth-definition.pdf

UNITED NATIONS OFFICE FOR DISASTER RISK REDUCTION UNISDR. (n.d.). *What is disaster risk reduction?* https://www.unisdr.org/who-we-are/what-is-drr

Walsh, S. (2014). Critiquing the politics of participatory video and the dangerous romance of liberalism. *Area*, 2014, doi: 10.1111/area.12104.

White, S.A. (2003). *Participatory video: Images that transform and empower.* Sage Publications.

Wong, N.T., Zimmermann, M.A., & Parker, E.A. (2010). A typology of youth participation and empowerment for child and adolescent health promotion. *Am J Community Psychol, 46,* 100–114.

Yang, K.H. (2016). Participatory video in adult education: Cultivating participatory culture in communities. SpringerBriefs in Education.

Knowledge, Attitude, and Practices of Infection Prevention and Control among Healthcare Workers

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Abstract

The study evaluates infection prevention and control (IPC) practices among Bais and Bindoy District Hospital healthcare workers. It aims to gauge their knowledge, attitudes, and practices concerning IPC, analyzing the relationships between these factors and respondents' demographic profiles. Using a non-experimental descriptive-correlational design, the researchers encompassed all healthcare professionals at these hospitals and employed a validated survey questionnaire. Statistical tools such as Cronbach Alpha, percentage, Mann Whitney U Test, Chi-square, and Kruskal-Wallis were utilized. Findings reveal adequate knowledge among respondents (mean score: 1.50), indicating lower susceptibility to hospital-acquired infections. The study also highlights a significant relationship between demographic profiles and knowledge and practices in IPC, though not with attitudes. No significant differences were found in IPC attitudes, knowledge, or practices when segmented by sex, age, length of service, or working department. The study underlines the lack of training courses as a key factor influencing professionals' knowledge and practices in IPC, recommending regular and comprehensive training programs alongside stringent adherence to updated standard operational procedures for all healthcare workers (HCWs) at these hospitals.

Keywords: Infection Prevention and Control, Health Practices, health knowledge, health attitude, health education

Introduction

Healthcare units today face challenges with an increasing number of patients who have acquired infectious diseases. According to Allegranzi (2011), Hospital-acquired Infections (HAIs), also known as "nosocomial infections" as defined by the World Health Organization (WHO), are infections acquired by the patient during the process of care in any healthcare facility that was not present at the time of admission. It also includes

occupational infections among staff. HAIs are known to be the most frequent adverse event in healthcare. However, they are also believed to be preventable with efficient and effective infection prevention and control. Recommendations to healthcare facilities include hand hygiene, wearing of Personal Protective Equipment (PPE), prevention of needle sticks and injuries from other sharp instruments, respiratory hygiene and cough etiquette, environmental cleaning, proper handling of lines, proper and safe disposal and proper handling of patient care equipment (Kumar & Kumar, 2015).

As reported in the National Conference of State Legislature, about 5 to 10% of all patients in intensive care units develop at least one hospital-acquired infection, also known as a healthcare-associated or nosocomial infection. According to the National Nosocomial Infections Surveillance (NNIS) program, nearly 1.7 million HAI cases and 99,000 deaths occurred in U.S. hospitals in 2002.

According to the United States' Office of Disease Prevention and Health Promotion, those infections may be linked to medical procedures (such as surgery) and medical equipment (such as catheters or ventilators). In the United States, HAIs are a leading cause of morbidity and mortality, and they are related to a significant rise in healthcare costs per year. At any given time, an H.A. affects one out of every 25 hospitalized patients in the United States.

In a study on Hospital-acquired infection in public hospital buildings in the Philippines, the study reported that the most common HAI was pneumonia (35 percent), and further, there were more respiratory HAI cases inwards near high-traffic areas, while for pediatric and adult patients, being immune-compromised is a risk factor for HAI (Vergeirr-Dalmacion et al., 2016).

According to WHO (2016), healthcare-associated infections do not exempt any country or facility in terms of their occurrence; hence, WHO launched the program "Clean Care is Safer Care in 2005 in response to these perennial concerns. The program focused on promoting hand hygiene at all levels of care. Hand hygiene is a very simple action and is well-accepted as one of the primary modes of reducing HAI and enhancing patient safety (Pittet, 2009). This program emphasizes the need for Infection Prevention and Control (I.P. & C) programs to be reinforced nationally at all facility levels. District hospitals have implemented and supported the program at their levels by following the heart of this program and accessible handwashing facilities in strategic areas. Besides, the Department of Health (DOH) has issued several guidelines that guide healthcare facilities, specifically on

infection prevention. The advisories and issuances include the National Standards of Infection Control for Healthcare Facilities, which states that healthcare administrators and staff be aware of, understand, and apply these standards as they pertain to respective roles, functions, and responsibilities (Department of Health, 2009); Administrative Order (A.O.) 2016-0002 which states the National Policy on I.P.& C in Healthcare Facilities; Department Memorandum (D.M.) No. 2020-0181, which states the reiteration of Infection Control Committee and Infection Control Team in Healthcare Facilities; Department Circular (D.C.) No. 2020-0106 adopted the WHO interim guidelines for health workers exposure Risk Assessment and management in the context of COVID-19 virus; D.M. No.2020-0167 which states the interim guidelines on the proper handling and disinfection of non-critical items used in the management of COVID-19 patients in all health facilities and Temporary Treatment and Monitoring Facilities (Of & Secretary, 2020); D.M. No.2020-0157 which states the guidelines on cleaning and disinfection in various settings as an I.P.& C measure against COVID-19 (Dm2020-0157 Guidelines on Cleaning and Disinfection in Various Settings. Pdf, n.d.); and Regional Circular (R.C.) No. 2020-20 on infection control and transport of patient's suspected with and confirmed case of COVID-19.

Infection Prevention and Control (I.P. & C) and practices are essential in maintaining a safe environment for everyone by reducing the risk of the potential spread of disease (Siegel et al. 2019). These practices are designed to reduce the risk of hospital-associated infections and to ensure a safe and healthy hospital environment for patients, healthcare providers, and visitors. I.P.& C is vital in delivering the health care system. Its primary role is to reduce the risk of acquiring hospital-acquired infections. It helps protect patients and staff from adverse infection-related outcomes (Torriani & Taplitz, 2012). HAIs can be reduced through surveillance, outbreak management, isolation, environmental hygiene, employee health, education, and infection prevention policies (Habboush et al., 2020).

However, some hospital policies on I.P. & C are not that well-defined. Bais District Hospital (BDH) in Bais City, Negros Oriental, and Bindoy District Hospital (BDH) in Bindoy, Negros Oriental, which are both infirmary levels of care, have been embracing the concept of the present health care delivery system. Both district hospitals share roles with other health facilities by providing and promoting quality patient care within their capabilities and resources. Over the years, these two district hospitals have existed and function purely as clinical/curative services. However, in pursuing comprehensive health care congruent with the National Health Plan and mandates, these hospitals have integrated health services' preventive

and rehabilitative aspects into the community family. While it has remained service-oriented, it cannot ignore the most pressing community health needs.

Yazie et al. (2019) posit that workplace health and safety are critical elements in every organization, particularly in healthcare settings. Healthcare workers are always at risk of being exposed to potential hazards. They are often the first to encounter infected patients. They can also be the source of infection as they can be a mechanical vector for transmitting nosocomial infections from patient to patient. Thus, a healthcare provider must be equipped with the Knowledge, Attitudes, and Practices (KAP) to adhere to infection prevention and control guidelines. This leads to a successful infection control program. The KAP model is one of the most used models in the medical field. This model was first used to determine family planning and population in the mid-nineteenth century. According to the KAP model, any activities (behaviors) are decided by the person's attitude and knowledge towards the behaviors (Alzghoul & Abdullah, 2015). Many KAP studies have been published online in different countries around the world and in different healthcare settings. Studies have shown that three Trinidad and Tobago hospitals generally have poor infection prevention KAP (Unakal et al., 2017). While a study in a Tertiary Hospital in Zambia reveals that they have performed well in knowledge and have a positive attitude towards infection prevention and control, their nurses had unsatisfactory practice levels, exposing them to infection-related diseases (Chisanga, 2017).

According to Wake, research shows that people in their various nations have a strong understanding, a positive attitude, and good practice regarding COVID-19. Researchers have identified factors related to COVID-19 knowledge, attitude, and practice in specific studies. Age, educational level, residence, monthly income, occupation, gender, marital status, and news media, for example, were all found to be significant contributors to knowledge. Age, occupation, educational level, monthly income, gender, place of residence, knowledge, and practice were all found to be significant predictors of attitude. Age, married status, educational level, domicile, monthly income, knowledge, gender, and attitude were all connected with practice substantially.

As observed, only a few KAP studies regarding I.P.& C have been published in the Philippines, and none so far in Negros Oriental, specifically in Bais District Hospital and Bindoy District Hospital. Therefore, the above research findings triggered the researchers to gather more information on KAP measures on I.P. & C among healthcare workers. The researchers, who are health workers serving the district hospitals in Bais City and Bindoy, Negros Oriental, utilized the findings to design a training or re-training program for the improvement of the knowledge, attitude,

and practices of health workers and formulate the necessary infections prevention and control policies suited for the health facility but aligned with the standards set by the WHO, DOH, and Center for Disease Control.

This study determined the level of knowledge, attitude, and practices on infection prevention and control among health workers in Bais and Bindoy District Hospitals. The study collected the respondents' socio-demographic profile regarding age, sex, education, profession, working department, length of service, and IPC training. Specifically, this research aimed to answer the following research questions: 1) What is the respondent's level of knowledge on infection prevention? 2) What is the attitude towards infection prevention among the respondents? 3) What are the practices of health care workers towards infection prevention? 4) Is there a significant relationship between respondents' socio-demographic profiles and knowledge, attitude, and practices? 5) Is there a significant difference in the respondents' knowledge, attitude, and practices when grouped according to age, sex, working department, and length of service?

This study limits itself to healthcare workers of Bais District Hospital located in Bais City, Negros Oriental, and Bindoy District Hospital in Bindoy, Negros Oriental, who met the eligibility criteria for respondents in I.P.& C. The researchers crafted, formulated, and adopted the Infection Prevention and Control Assessment Form for Hospital Managers and Healthcare Professionals in the Context of COVID-19(Validation Tool for Infection Prevention and Control as per D.M. No, n.d.) and modified the style of the Survey Questionnaire in observing the KAP on I.P.& C among respondents. This study was conducted from July 1-31, 2021, and was funded by the Technical Assistance Package Program (TAPP) of the Department of Health.

Related Literature

The use of nursing theories in I.P. & C acknowledges that many models and theories are specialized. For example, Roper, Logan, and Tierney's model and use of maintaining a safe environment are relevant to infection prevention and other theories, such as Nightingale's environmental theory and Dorothy Johnson's Behavioral Systems Theory. The educational theory has also been used to develop infection prevention and control link nurse programs.

Florence Nightingale's nursing theory identified the four metaparadigms: individual, environment, health, and nursing. Each of the four principles is related to the others. A person is a living being influenced

by their surroundings and acted upon by a nurse. The environment is how a nurse can manipulate natural laws to act to make the human body healthy or vice versa (Sayani, 2017).

Environmental theory paved the way for developing infection control practices in our healthcare systems today. The theory assumes that a suitable environment helps patients recover. It focused on disease prevention and health promotion, bringing a new clinical nursing approach (Gilbert, 2020). It emphasized the importance of hygiene and patient care in infection prevention and control. Currently, two recommended precautions are introduced to prevent or stop an infection in any healthcare setting. These are the standard precaution and the transmission-based precaution. The standard precautions are the bare minimum procedures required to achieve infection prevention and control at the most basic level. It aims to reduce or eliminate the risk of transmission from pathogens or bloodborne, both from recognized or unknown sources. Standard precautions include hand washing; use of Personal Protective Equipment (PPE) such as gloves, masks, face shields, eye protection, and gowns; prevention from a needle or other sharp injuries; environmental cleaning; appropriate handling of linens; environmental cleaning; waste disposal; respiratory hygiene and cough etiquette; and reprocessing or reusable equipment and instruments. Transmission-based precaution is used in addition to standard precaution. It comprises the following: droplet precaution, contact precaution, and airborne precaution (Chris, 2015). This study focused on the standard precautions for infection prevention and control. Healthcare staff is at a greater risk of contracting infectious diseases if they do not practice proper infection control. Thus, up-to-date healthcare worker's knowledge and practice can play essential roles in infection prevention and control. Data was collected using a structured questionnaire to assess the health workers' levels of knowledge, attitude, and practices. The KAP survey is easy to design, and the data input can be quantifiable, making it suitable for this study.

KAP surveys were first developed in the 1950s. After 1960, KAP surveys were extensively employed in many countries to research birth control practices (Rav-Marathe et al., 2016). The KAP studies are cheaper and conserve resources than other social research methods because they are tightly focused and limited in scope (Rav-Marathe et al., 2016).

This research framework has been widely utilized in the health education field and within the developing world for birth control. As a guide to understanding the mechanisms of health education for patient behavioral changes and patient health outcomes, KAP surveys are now a widely used methodology for studying human behavior when faced with a problem

(Unakal et al., 2017).

KAP surveys established their place among the methodologies utilized to investigate health behavior. Today, they are still widely used to gain information on health-seeking practices. In KAP surveys, the knowledge part is generally used only to assess the extent of community knowledge about public health concepts related to national and international public health programs. Measuring attitudes is the second part of a regular KAP survey questionnaire. On the other hand, many KAP research does not present findings on attitudes, owing to the significant risk of incorrectly generalizing a single group's views and attitudes. Attitudes are interlinked with the person's knowledge, beliefs, emotions, and values, and they are either positive or negative. The third and integral part of KAP surveys is the investigation of health-related practices. Questions typically concern the utilization of various treatment and prevention options. KAP surveys are criticized for providing only descriptive data, which fails to elucidate why and when specific treatment prevention and practices are chosen (Launiala, 1970).

KAP survey data is usually utilized to plan activities aimed toward behavior, supported by the false assumption that knowledge and behavior have a direct relationship. Several studies have shown that knowledge is just one factor influencing treatment-seeking practices and varied behavior. Health programs must address multiple factors, from socio-cultural to environmental, economic, and structural (Launiala, 1970).

The theory of planned behavior has previously been utilized in infection prevention and control. It uses a self-administered questionnaire that supports Planned Behavior's idea to identify handwashing predictors in hospital and community settings in Iranian healthcare workers. It identifies several predictors, including compliance with similar practices. It is also noted that the perception of handwashing requiring little effort and peer pressure affected reported behavior. Attitudes towards handwashing were also identified (Ogoina et al., 2015). The theory of planned behavior is founded on the premise that people are reasonable, use data in a structured way, and weigh the consequences of their actions before acting (Kretzer & Larson, 1998). The best predictor of behavior is intention, often impacted by three main aspects: attitude towards the behavior, subjective norm, and behavioral control.

Montaño (1992) elucidates on the Theory of Planned Behaviour. He states that "a person's behavior is decided by his/her intention to perform that behavior. The intention is made by his/her attitudes toward that behavior, his/her beliefs about what others think he/she should do, his/her motivation

that suits others' needs, and perceived behavioral control. When an individual finds an action positive and significant others approve of it, they are more likely to carry it out." He also points out that behavioral purpose does not always translate into actual actions due to environmental and contextual factors. The idea of planned behavior does not consider such interaction effects. It follows a rational path, but human behavior is not always predictable. In either case, the indicators of self-care habits are patients' actual acts, not just their plans to act.

The Theory of Planned Behavior adds to Reasoned Action's idea because it includes the concept of perceived behavioral control, which may be a person's belief that they need control over their behavior despite potential barriers. In infection prevention and control, students may believe they will comply with hand hygiene despite barriers like time and workload. This assumption would then directly impact the decision to practice hand hygiene and, thus, indirectly on the actual practice of hand hygiene. However, what must be considered here is that someone may perceive the need to control behavior (perceived behavioral control) and behave in a specific way. However, if this perception of control is flawed and someone or something else holds control, the implications could be significant. In that case, the intended behavior might not occur. For example, suppose there is no access to hand hygiene facilities. In that case, external influences prevent the behavior despite intending to perform hand hygiene. The idea of behavioral control is even low with past behavior, for instance, if the student has previously been a health care assistant who failed to comply with hand hygiene or past success or failure at behavior.

Moreover, the Health Belief Model (HBM) has also been used as an explanatory framework to know health professionals' infection prevention and control practices. According to the HBM, behavioral change is influenced by a person's background, including socio-demographic factors, personal perceptions, and cues to action. The HBM defined perceived risk/susceptibility to infection as one of the factors predicting infection control activities and the microorganism's perceived severity ("infectiousness" and consequences). If healthcare workers do not perceive themselves as at risk for their safety, they are less likely to adopt IPC precautions. Perceived benefits are another predictive element in this model of IPC behavior. Previous research has shown that as medical students progress towards the ultimate years of their training, they are less likely to work out the worth of hand hygiene to protect themselves from acquiring antibiotic-resistant microorganisms and prevent carrying microorganisms home. Higher self-efficacy facilitates increased effort and persistence towards particular

behaviors (Cox et al., 2015).

Education and training of healthcare workers (HCWs) within the theory and practice of I.P.& C are widely considered critical measures to scale back the chance of HAI. I.P.& C education provides HCWs with a knowledge domain and insight that act as a driving force behind future activities. In contrast, IPC training is task-orientated within a particular working milieu. It helps HCWs to obtain skills to complete clinical procedures in line with the set standards of care. In their publications and guidelines, leading organizations within I.P.& C like the (WHO), DOH, and, therefore, the Centers for Disease Control and Prevention (CDC) consistently emphasize the necessity for continuous IPC training of all HCWs.

Dorothy Johnson is known for her "Behavioral System Model of Nursing," first proposed in 1968. Her nursing model states, "Each individual has patterned, purposeful, repetitive ways of acting that comprise a behavioral system specific to that individual." It promotes efficient and effective patient behavior to prevent sickness and emphasizes the relevance of research-based understanding regarding the impact of nursing care on patients. Dorothy Johnson began her work on the model of the notion that nursing was a unique profession that contributed significantly to society's well-being. As a result, nursing had a clear purpose of action regarding patient welfare.

The goals of nursing, according to the Behavior System Model, are fourfold: (1) to assist the patient whose behavior is proportional to social demands; (2) To help the patient who can change his behavior in ways that are consistent with biological imperatives. (3) To assist the patient who can benefit the most from the physician's knowledge and skill during their illness. Furthermore, (4) to support the patient whose behavior does not indicate that he or she has been subjected to undue trauma as a result of disease.

Watson's Philosophy and Science of Caring is about how nurses show their patients they care. Her perspective emphasizes the humanistic components of nursing concerning scientific knowledge and nursing practice. The nursing model states that "nursing is concerned with promoting health, preventing illness, caring for the sick, and restoring health." which emphasizes both disease prevention and treatment. Watson claims that caring is at the heart of nursing practice and promotes health more effectively than a simple medical solution. She believes a holistic approach to health care is essential to nursing practice. Nurses, according to her notion, can display and practice caring. Loving for patients encourages development; a caring atmosphere embraces people for who they are while anticipating

what they may become. Research across diverse healthcare settings globally reveals that demographic factors such as gender, age, professional role, and education significantly influence healthcare workers' (HCWs) knowledge, attitudes, and practices (KAP) in infection prevention and control (IPC). For instance, a study in China found that nurses and female HCWs had higher compliance with IPC practices than other demographic groups, reflecting their direct engagement with patient care and possibly enhanced awareness of IPC risks (Zhang et al., 2020). In Nigeria, IPC compliance was also significantly higher among female HCWs and nurses, with factors like more extended work experience and advanced education levels positively impacting knowledge and practices, suggesting that experience reinforces adherence to IPC standards (Azuogu et al., 2021).

In the United States, research indicates mixed effects of age and gender on IPC practices, with younger HCWs often showing higher knowledge scores due to recent IPC-focused training, although longer-tenured staff tend to perform better in practice adherence, potentially due to experiential knowledge (Gammon et al., 2022). Similarly, an Australian study noted that higher educational attainment positively influenced IPC knowledge, with HCWs holding tertiary degrees demonstrating better IPC practices, likely due to formal training in IPC protocols (Lawson et al., 2021).

The occupational role is another crucial factor. In Saudi Arabia, for example, studies revealed that HCWs in high-acuity settings, such as intensive care units, displayed greater compliance with IPC protocols, as these environments present heightened exposure to infectious agents, making adherence essential (Alwafi et al., 2021). This pattern aligns with studies in Japan, where HCWs in emergency departments reported higher IPC adherence, likely due to departmental protocols and regular IPC training specific to high-risk patient care settings (Nakano et al., 2020).

Further, studies from various countries have demonstrated that demographic factors influence healthcare workers' (HCWs) knowledge, attitudes, and practices (KAP) in infection prevention and control (IPC) with significant variability across age, gender, education, and professional roles. For instance, a study in Nigeria on IPC adherence following a Lassa fever outbreak found that gender and job role significantly affected IPC compliance, with nurses and female HCWs showing higher adherence to protective practices than their male counterparts. The findings suggested that women and nurses often filled direct patient care roles, which could enhance compliance (Azuogu & Ogah, 2021).

In contrast, a study from Australia observed that IPC knowledge and practice scores were generally higher among HCWs with greater work

experience and higher education levels. Professionals holding postgraduate degrees were significantly more likely to adhere to IPC guidelines than those with only diploma qualifications, highlighting the influence of formal education on IPC practice (Lawson et al., 2021).

In Saudi Arabia, a study during the COVID-19 pandemic revealed that professional roles and workplace settings influenced IPC attitudes and practices. HCWs in high-acuity areas such as emergency and intensive care units demonstrated greater adherence to IPC protocols than those in outpatient or administrative roles, likely due to the increased risk perception in high-infection environments (Alwafi et al., 2021). Similarly, a study of dental professionals in the United States found no major differences in IPC attitudes based on age or gender; however, dental assistants showed higher knowledge scores than dentists, possibly due to greater IPC training and hands-on exposure in their roles (Journal of Contemporary Dental Practice, 2022).

Methodology

This study utilized a non-experimental descriptive-correlational research design. It aimed to determine the level of knowledge, attitude, and practices on infection prevention and control among health workers in Bais and Bindoy District Hospitals. This also identified the relationship between the respondents' knowledge, attitude, and practices on infection prevention and control and their socio-demographic profile. Moreover, ethics approval was sought from the Silliman University Research Ethics Committee.

This study was conducted in Bais District Hospital and Bindoy District Hospital in the province of Negros Oriental. Both hospitals are licensed as infirmary level of care by the DOH. This was chosen as the research environment because the researchers utilized the findings to formulate protocols on infection prevention and control that are suited for the health facility but aligned with the standards set by the DOH and designed a program for re-training health care workers.

The researchers utilized a total enumeration of respondents. Bais District Hospital has 70 healthcare workers, while Bindoy District Hospital has 30. A total population of 100 healthcare workers for both hospitals was asked to answer the survey questionnaire with the inclusion criteria of healthcare workers currently employed in Bais and Bindoy District Hospitals who are directly involved in the care of patients, specifically doctors, nurses, medical technologist, midwife, nursing aides, and institutional workers.

This study utilized a survey questionnaire to gather self-report

information from respondents through the self-administration of questions in a paper and pencil format. The questionnaire was crafted, formulated, and adopted from the Infection Prevention and Control Assessment Form for Hospital Managers and Healthcare Professionals in the Context of COVID-19 (Validation Tool for Infection Prevention and Control as per D.M. No, n.d.). Healthcare workers are expected to carry out the listed items as part of ideal practices for Infection Prevention and Control (I.P. & C.).This study has four (4) parts. The first part seeks the socio-demographic and health profiles of the respondents. The second part consists of eleven (11) questions that measure the level of knowledge. Each question has four (4) alternative responses represented by numbers: 4 for strongly disagree (firmly opposed the idea); 3 for disagree (does not accept the idea); 2 for agree (acknowledge the idea); and 1 for strongly agree (fully acknowledge the idea). The 3rd part consists of eleven (11) questions that measure the attitude. The 4th part consists of eleven (11) questions. Each question has four alternative responses represented by numbers, 4 for never (not performing at all), 3 for rarely (not performing in the regular interval), 2 for often (frequently performing it), and 1 for always (performing it at all times).

Considering that the instrument was researcher-prepared, it was subjected to subjective and objective procedures to determine its validity and reliability. Experts in the field perform the former, while the latter is through statistical means. A validated self-administered questionnaire comprising four sections (socio-demographic, knowledge, attitude, and practice) was used for data collection. After completion of the initial draft of the survey questionnaire was validated and adopted as follows: firstly, the questionnaire was sent to two experts knowledgeable in the area. After coordination and consensus of all experts' opinions, the final questionnaire was drafted, and pilot testing was performed on 30 individuals at Congressman Lamberto Macias Memorial Hospital (CLMMH) to confirm the reliability of the questionnaire. The data from the pilot study were loaded into SPSS 20 and subjected to reliability coefficient analysis. The overall Cronbach's alpha reliability coefficient of KAP questions was 0.91.

Data was collected and analyzed using Cronbach Alpha, percentage, weighted mean, Chi-square test of independence, Mann-Whitney U test, and Kruskal-Wallis test. Cronbach Alpha was used to determine the extent of reliability of the questionnaire. On the other hand, percentage was utilized to present the respondents' distribution in terms of their profile and attitude. The chi-square test of independence was used to determine the significant relationship between the nominal data in the profile, which goes beyond

two categories: knowledge, attitude, and practices. Moreover, the Mann-Whitney U test was used to determine if there was a significant difference when the respondents were grouped in terms of sex. Lastly, the Kruskal-Wallis test was used to determine whether or not a significant difference exists in knowledge, attitude, and practices when the respondents are grouped in terms of their profile. Since these statistical tools are standard, their respective formulas need not be shown.

The proposed study was sent to the Silliman University Ethics Review Board on March 29, 2021, and was approved on June 28, 2021.

Results and Discussion

One hundred (100) HCWs were approached, agreed to participate, and completed the KAP infection prevention and control survey. Out of 100 respondents, results showed that in terms of respondents' sex, 71 or 71% are female, and 29 or 29% are male.

In terms of age, out of 100 respondents, 44 or 44% of the total respondents who belong to the age range of 26-35 years old ranked first and garnered the highest number while both age ranges from 18-25 years old and above 56 years old got the lowest rank among age groups. In addition, out of 100 respondents, 67 or 67% were married and provided the highest result, while 1 or 1% of respondents were a widow and showed the lowest result. Moreover, in terms of respondents' professions, out of 100 respondents, nurses ranked first and showed 31 or 31% of the total respondents, while 8 or 8% shows medical laboratory technicians with the lowest rank. In terms of educational level, results showed that out of 100 respondents, both four-year degree and two-year degree courses got 29 or 29% and were ranked first, while 7 or 7% of the respondents did not specify their degrees in the survey questionnaire.

Likewise, results revealed that out of 100 respondents, 40 or 40% chose Others, ranked first when asked about their work department. Results also revealed that out of 100 respondents, 25 or 25% of the respondents revealed that their work experiences had reached 6-10 years and were ranked the highest, while 3 or 3% of the respondents who did not indicate their work experiences were ranked the lowest. Further, out of 100 respondents, 49 or 49% of the respondents revealed that they worked for eight (8) per day, and this showed the highest number and was ranked first, while 13 or 13% of the respondents who responded Others ranked third.

Regarding Training on Infection Prevention and Control, out of 100 respondents, 72 or 72% answered "No" when asked about their Training in

IPC and was ranked first, while 2 or 2% of the total respondents did not indicate their answers to the question. Finally, out of 100 respondents, results revealed that 94 or 94% of the respondents were fully vaccinated while 6 or 6% were not vaccinated yet.

Table 1

Respondent's Level of Knowledge, Attitude, and Practices Regarding Infection Prevention and Control

Item	1(%)	2(%)	3(%)	4(%)	WX	VD
I am aware of the current Institutional guidelines regarding Infection Prevention and Control in my facility.	31	45	14	10	2.03	Agree
I know how to properly assess patient placement.	49	42	0	9	1.69	Strongly Agree
I am aware of the WHO approach on "5 Moments of Hand Hygiene" and correct sequence of proper hand washing.	66	30	2	2	1.5	Strongly Agree
I know how to disinfect and decontaminate the patient-care equipment and my workstation.	63	29	6	2	1.47	Strongly Agree
I know how to maintain and provide a safe and clean surface environment for my patients.	60	36	1	3	1.47	Strongly Agree
I know how to perform proper donning and doffing of PPE.	61	34	4	1	1.45	Strongly Agree
I know how to properly segregate health care waste based on this institution's color-coding scheme.	62	36	1	1	1.41	Strongly Agree
I know when to use appropriate PPE when caring for each patient.	65	33	1	1	1.38	Strongly Agree
I know how to dispose used PPE properly.	66	32	1	1	1.37	Strongly Agree
I know that recapping of used needles can increase needle stick injury.	70	26	1	3	1.37	Strongly Agree
I know where to dispose sharps properly.	73	23	1	3	1.34	Strongly Agree
Aggregate					1.50	Strongly Agree

Verbal Description: (1)SA= Strongly Agree (1.00-1.74); (2) A Agree (1.75-2.49); (3)D= Disagree (2.50-3.24); (4)SD= Strongly Disagree (3.25-4.00

Table 1 presents data on the respondents' level of knowledge regarding infection prevention and control. The findings indicate that the highest level of knowledge was demonstrated in their agreement with Item 2, which had a weighted mean of 2.03, suggesting that respondents believe they are familiar with the current institutional guidelines on infection prevention and control.

In descending order, respondents strongly agreed with the following items: Item 1, 'I know how to properly assess patient placement,' with a weighted mean of 1.69; Item 3, 'I am aware of the WHO approach on the "5 Moments of Hand Hygiene" and the correct sequence of proper hand washing,' with a weighted mean of 1.50. Item 8, 'I know how to disinfect and decontaminate patient-care equipment and my workstation,' and Item 9, 'I know how to maintain and provide a safe and clean surface environment for my patients,' had a mean of 1.47. Item 5, 'I know how to perform proper donning and doffing of PPE,' had a weighted mean of 1.45; Item 7, 'I know how to properly segregate healthcare waste according to the institution's color-coding scheme,' had a weighted mean of 1.41; and Item 4, 'I know when to use appropriate PPE when caring for each patient,' had a weighted mean of 1.38. Both Item 6, 'I know how to properly dispose of used PPE,' and Item 11, 'I know that recapping used needles can increase the risk of needle-stick injury,' had weighted means of 1.37. Lastly, Item 10, 'I know where to dispose of sharps properly,' had a weighted mean of 1.34.

Overall, the mean knowledge score of 1.50 indicates that respondents possess an adequate understanding of infection prevention and control, suggesting they are less likely to contract hospital-acquired infections."

These findings align with a study conducted at a Zambian tertiary hospital by Chisanga (2017), which reported that most participants demonstrated a strong understanding of infection prevention and control, achieving an average score of 83.21. In contrast, a study by Unakal et al. (2017) conducted across three regional hospitals in Trinidad and Tobago revealed that only 20.3% of 300 healthcare workers were knowledgeable about infection prevention measures, while the remaining 79.7% lacked awareness of infection prevention and control protocols.

Table 2 presents data on respondents' attitudes toward infection prevention and control. The results indicate that all 100 respondents (100%) expressed strong agreement (SA) with all survey items regarding their attitudes. Item 2 ('I will adhere to Infection Prevention & Control practices based on the institution's policies') ranked highest, with a weighted mean of 1.42. Respondents also strongly agreed with the following items ranked in descending order: Item 4 ('I believe that wearing appropriate PPE can protect me from acquiring any infectious diseases') with a weighted mean of 1.32; Item 3 ('I believe that hand hygiene is the most effective measure to avoid transmission of infections') at 1.27; and Item 5 ('I believe that correct donning and doffing of PPE is crucial when caring for patients') at 1.26. Item 1 ('I believe that proper patient placement reduces the risk of infection transmission') recorded a mean of 1.24.

Items 7 ('I believe that proper waste segregation and disposal help prevent the spread of infectious diseases'), 8 ('I believe that patient-care equipment should be cleaned and disinfected after each use'), and 9 ('I believe that regular disinfection of high-touch surfaces enhances patient safety') shared a mean of 1.23. Items 6 ('Proper trash bins are essential where I doff PPE') and 10 ('Sharps should be discarded in a puncture-proof container') recorded a mean of 1.20. Item 11 ('I believe in using "one needle, one syringe" at a time') ranked last, with a mean of 1.18.

Overall, the aggregate mean score for the respondents' attitudes was 1.25, indicating a strong agreement and a positive outlook towards infection prevention and control measures.

These findings are congruent with the study entitled Knowledge, Attitude, and Practice of Infection Control among Primary Care Professionals in Abha City, Kingdom of Saudi Arabia (Al-Ahmari et al., 2021), which revealed that about one-third of the participants (31.6%) had poor knowledge about infection control and 88.2% had a positive attitude toward infection control policy and procedures. Furthermore, a KAP research conducted in Nigeria revealed a 90 percent positive attitude toward basic precautions. The results of these two studies are higher than those of Unakal et al. 's studies in Trinidad and Tobago. Less than half of the survey participants (46.7 %) showed a positive attitude toward infection prevention, highlighting their HCWs' overall negative attitude.

Table 2
Level of Attitude

Item	1(%)	2(%)	3(%)	4(%)	WX	VD
I will adhere with Infection Prevention & Control practices based on institution's policies.	61	35	2	1	1.42	Strongly Agree
I believe that wearing appropriate PPE can protect me from acquiring any infectious disease.	81	16	0	2	1.32	Strongly Agree
I believe that hand hygiene is the most effective measure to avoid transmission of infections.	79	15	3	2	1.27	Strongly Agree
I believe that correct donning and doffing of PPE is crucial when caring for any patients following standards and transmission-based precautions.	77	19	0	2	1.26	Strongly Agree
I believe that proper patient-placement reduce the risk of transmission of infection	77	21	0	1	1.24	Strongly Agree
I believe that proper waste segregation & disposal helps prevent the spread of infectious disease.	80	17	0	2	1.23	Strongly Agree
I believe that patient-care equipment should be cleaned & disinfected every after use of each patient or before using to another patient; and workstations should be disinfected.	80	17	0	2	1.23	Strongly Agree
I believe that regular disinfection and decontamination of the high-touch surface in my patients' environment will keep them safe.	79	18	1	1	1.23	Strongly Agree
It is important to me that proper trash bins are available where I doff my PPE	81	17	0	1	1.2	Strongly Agree
I believe that sharps should be discarded in a punctured-proof container	81	17	0	1	1.2	Strongly Agree
I believe in "one needle, one syringe" at one time.	85	12	0	2	1.18	Strongly Agree
Aggregate					1.25	Strongly Agree

Verbal Description: (1)SA= Strongly Agree (1.00-1.74); (2)A= Agree (1.75-2.49); (3)D= Disagree (2.50-3.24); (4)SD= Strongly Disagree (3.25-4.00).

Table 3 presents data on the respondents' infection prevention and control (IPC) practices. The results indicate that respondents consistently selected 'Always' for all 10 items related to their IPC practices. Notably, Item 9, 'I properly disinfect and decontaminate high-touch surfaces and areas within a 3-foot proximity of the patients' environment,' ranked highest with a weighted mean of 1.80.

Respondents also expressed strong agreement with the following items, ranked from second to last, along with their corresponding weighted means: Item 2, 'I follow the institution's IPC guidelines throughout my tour of duty' (1.74); Item 8, 'I properly disinfect and decontaminate patient-care equipment and workstations during my tour of duty' (1.61); Item 1, 'I properly assign patients to their appropriate rooms/wards' (1.53); Item 5, 'I strictly adhere to the sequence of proper donning and doffing of PPE' (1.38); Item 4, 'I use appropriate PPE when caring for patients, following standards and transmission-based precautions' (1.34); and Item 3, 'I wash my hands properly, following WHO's "5 Moments of Hand Hygiene" using the correct technique and duration' (1.28).

Furthermore, Item 7, 'I practice proper segregation and disposal of waste in all areas of the hospital,' received a weighted mean of 1.27; Item 6, 'I properly discard used PPE in the appropriate trash bin' (1.24); and Items 10 and 11, 'I properly discard sharp materials directly into safety boxes or puncture-proof containers' and 'I use "one needle, one syringe" for each patient,' both received a weighted mean of 1.22, ranking last.

The overall mean score for respondents' IPC practices was 1.42, indicating that many respondents consistently chose 'Always.' These results suggest that respondents exhibit good IPC practices, reinforcing the implementation of safety measures in their workplace.

A 2021 study titled Knowledge, Attitudes, and Practices Regarding COVID-19 Prevention among Vietnamese Healthcare Workers (Tien et al., 2021) reported that healthcare workers in Daklak province, Vietnam demonstrated substantial knowledge (91.3%), maintained a positive attitude (71.5%), and engaged in appropriate practices (83.1%) related to COVID-19 prevention. In contrast, research conducted by Ogoina et al. in Nigeria indicated a median practice score of 50.8%, reflecting poor overall adherence to standard infection prevention and control protocols among Nigerian healthcare workers.

Yakob et al. reported that among 135 respondents, 57 healthcare workers (42.2%) consistently adhered to standard precautions, 59 (43.7%) disposed of sharp materials in open pails, and 63 (46.8%) consistently used standard blood and body fluid precautions. The study concluded that while healthcare workers displayed a generally favorable attitude toward standard precautions, their knowledge and practice fell short of meeting the expected standards, indicating overall insufficiency.

Table 3
Level of Practice

Item	1(%)	2(%)	3(%)	4(%)	WX	VD
I properly disinfect and decontaminate high-touch surfaces and areas of close proximity (3 feet) of the patient.	52	28	6	13	1.80	Often
I follow the institution's IP & C guidelines throughout my tour of duty.	60	20	6	14	1.74	Always
I properly disinfect and decontaminate patient-care equipment and workstations during my tour of duty.	61	24	8	7	1.61	Always
I properly assign patients to their appropriate rooms/ward.	71	16	2	11	1.53	Always
I strictly adhere to the sequence of proper donning and doffing of PPE.	70	25	2	3	1.38	Always
I use appropriate PPE when caring for patients following standards and transmission-based precautions.	73	22	3	2	1.34	Always
I wash my hands properly following WHO's "5 moments of hand hygiene" using the correct technique and time duration.	76	22	0	2	1.28	Always
I practice proper segregation and disposal of waste in all areas of the hospital.	78	19	1	2	1.27	Always
I properly discard my used PPE in the appropriate trash bin.	82	14	2	2	1.24	Always
I properly discard sharp materials directly into the safety box or punctured-proof containers.	87	8	1	4	1.22	Always
I only use "one needle, one syringe" at one time.	88	7	0	5	1.22	Always
Aggregate					1.42	Always

Verbal Description: (1)A= Always (1.00-1.74); (2)O= Often (1.75-2.49); (3)R= Rarely (2.50-3.24); (4) N= Never (3.25-4.00).

Table 4 shows that among the respondents' profiles, only the working department, PPE availability, and source of information on safety precautions are significantly related to knowledge. This is exemplified in their respective p values, which are less than the margin of error at 0.05. Specifically, the Working Department has a p-value of 0.02 (less than the significance level of 0.05), and those in the OPD, Lab Room, and ER are the top 3 with the lowest ratings (within 1.00-1.74), which means that they Strongly Disagree on the infection and prevention control. For the variable Source of Information, the p-value is 0.00, which is below the significance level of 0.05. This indicates a statistically significant difference.

Respondents who cited training programs, a combination of various sources, and guidelines as their primary sources of information had the lowest ratings (ranging from 1.00 to 1.74). This suggest that they Strongly Disagree with statements related to infection prevention and control. Furthermore, those respondents who answered "Yes" and "No" on PPE Availability got a p-value of 0.02 (less than the significance level of 0.05) and showed lower ratings (within Strongly Disagree) compared to those who said they were not sure.

Table 4

Relationship between Socio-Demographic Profile and Knowledge

Knowledge and	χ^2	**p**
Sex	0.06	0.81
Age	4.89	0.30
Marital status	2.90	0.23
Profession	5.41	0.25
Educational level	5.66	0.23
Working department	12.09	0.02*
Work experience	1.52	0.82
Working hours per day	1.27	0.53
Training on IPC	2.56	0.11
Vaccination	3.03	0.08
PPE availability	8.04	0.02*
IPC guidelines availability	2.14	0.34
Source of information on safety precautions	13.20	0.00*

In a study conducted by Ogoina et al. in Nigeria, a total of 290 HCWs participated in the study (76% response rate), including 111 (38.3%) doctors, 147 (50.7%) nurses, and 32 (11%) laboratory scientists. The result shows that House officers, laboratory scientists, and junior cadres of nurses had lower knowledge and compliance with standard precautions than more experienced doctors and nurses.

In another study conducted by Tien et al., findings revealed that healthcare workers (HCWs) accessed COVID-19 information primarily from three primary sources: the Ministry of Health's website (97.7%), television (97.5%), and the Internet (96.7%). Additionally, over 80% of respondents utilized supplementary sources, including radio, newspapers, and input from relatives, friends, or colleagues. The study indicated that 83.8% of HCWs considered the information accurate, while 12.6% believed there was an overabundance. The remaining participants either possessed limited knowledge or none at all. The results highlighted an average knowledge score of 963, with 91.3% (879 HCWs) achieving high scores. Significant differences in mean knowledge scores were observed across

gender, educational level, and occupational groups.

Female health workers, those holding bachelor's or master's degrees, and doctors or technicians masks, respectively. However, 52.1% of respondents indicated they felt the demonstrated greater knowledge of COVID 19 compared to other groups ($P < 0.5$).

The results in Table 5 show no significant relationship between the respondents' socio-demographic profile and their attitude toward infection prevention and control. This is exemplified in their respective p values, greater than the margin of error at 0.05. Like Sex, with a p-value of 1.00; Age, with p-value of 0.37; Marital Status, with p-value of 0.50; Profession, with p-value of 0.15; Educational level, with p-value of 0.06; Working department, with p-value of 0.30; Work experience, with p-value of 0.52; Working hours per day, with p-value of 0.77; Training of IPC, with p-value of 0.78; Vaccination, with p-value of 0.50; PPE availability with 0.17; IPC guidelines ability, with p-value of 0.67; and Source of information on safety precautions, with p-value of 0.39. The study shows no significant relationship between the socio-demographic profile of the respondents and their attitude toward infection prevention and control.

Table 5

Relationship between Socio-Demographic Profile and Attitude

Attitude and	χ^2	p
Sex	0.00	1.00
Age	4.30	0.37
Marital status	1.40	0.50
Profession	6.70	0.15
Educational level	9.30	0.06
Working department	4.85	0.30
Work experience	3.22	0.52
Working hours per day	0.52	0.77
Training of IPC	0.08	0.78
Vaccination	0.46	0.50
PPE availability	3.59	0.17
IPC guidelines availability	0.81	0.67
Source of information on safety precautions	3.01	0.39

Reuben (2020) reported that 589 individuals participated in a survey conducted in North Central Nigeria. Of these respondents, 80.6% were aged between 18 and 39, 59.6% were male, 90.4% held a bachelor's degree or higher, and 56.2% resided in urban areas. The survey was predominantly composed of male respondents (59.6%) and single individuals (60.1%), with most participants having a college-level education or higher (90.4%). The

data revealed a high level of awareness of COVID-19 among respondents, with 99.5% acknowledging awareness of the pandemic. Additionally, 79.5% expressed confidence in government infection prevention and control (IPC) easures, while 92.7%, 96.4%, and 82.3% adhered to practices such as social distancing/self-isolation, enhanced personal hygiene, and wearing face Nigerian government was not taking sufficient action to address COVID-19.

According to Tien et al., the overall score of attitudes ranged from 0 to 8. 71.5 % of HCWs expressed positive feelings about COVID-19 prevention, whereas 28.5 % expressed unfavorable feelings. There were no significant differences in attitudes among age groups, education levels, occupations, residences, or workplaces. The only significant difference was revealed to be gender. Female employees had a higher attitude score than male employees (P =.042).

Unakal et al. discovered that 140 workers (46.7 %) had a positive attitude toward infection prevention, while 160 workers (53.3 %) did not. In general, they responded negatively to queries on their attitudes (70 %). There is no significant link between age, sex, or educational status and attitude, according to socio-demographic factors ($p>0.05$). However, ethnicity, work experience, and attitude had a significant relationship ($p<0.05$).

Table 6

Relationship between Socio-Demographic Profile and Practices

Practices and	χ^2	**p**
Sex	0.67	0.41
Age	4.97	0.29
Marital status	2.12	0.15
Profession	18.36	0.00*
Educational level	18.32	0.00*
Working department	8.99	0.06
Work experience	3.06	0.55
Working hours per day	4.57	0.10
Training on IPC	0.05	0.82
Vaccination	4.50	0.03*
PPE availability	6.31	0.04*
IPC guidelines availability	19.28	0.00*
Source of information on safety precautions	1.08	0.78

Table 6 showed that among the respondents' profiles, only profession, educational level, vaccination, PPE, and IPC guidelines availability are significantly related to practices. This is exemplified in their respective p values, which are less than the margin of error at 0.05. Results revealed that, in terms of Profession, with a p-value of 0.00 (less than the significance level of 0.05), Midwifery/nursing aids, med lab, and nurses were at the top

3 who Strongly Disagree (within 1.00-1.74) on their perception about their infection prevention and control practices. It denotes that one's profession is affecting one's practices. In terms of Vaccination, with a p-value of 0.03 (less than the significance level of 0.05); PPE Availability, with a p-value of 0.04 (less than the significance level of 0.05); and IPC guidelines, with p-value of 0.00 (less than the significance level of 0.05), results showed that there was a higher percentage in respondents who answered "Yes" they strongly disagree on infection prevention and control compared to those who answered "No" and "Not Sure." On the other hand, in terms of respondents' educational level, with a p-value of 0.00 (less than the significance level of 0.05), those with 2-year courses, 4-year courses, and graduate courses were the top 3 who strongly disagreed on infection and prevention control practices.

In a study conducted by Tien et al., most HCWs (83.1%) completed all six steps for preparing for COVID-19, whereas 16.9% of respondents had insufficient experience. It means that one out of every six HCWs was not following COVID-19 preventive measures to the letter. Up to 89.6% of participants said they had difficulty implementing preventive measures. More than half of the 863 HCWs who had trouble adopting measures (56.4%) said it was difficult to modify their daily practices, and 40% said they lacked personal protective equipment such as face masks (N95), gloves, face shields, gowns, and sanitizer. Other obstacles mentioned were the inconvenience of putting these measures into effect (14.4 %), feeling uncomfortable (3 %), and feeling unnecessary (1.7 %).

In Unakal et al.'s study, 12 questions were asked to assess infection prevention measures among HCWs. It shows that 132 workers (44 %) had good habits, while 168 workers (56 %) did not. In general, they have a negative response to practice-related inquiries (70 % There was no statistically significant relationship between socio-demographic factors and their practices ($p>0.05$).

Desta et al. found out that in the practice of IPC, there is a substantial association between respondents' age, educational level, work experience, trainings, and availability of PPE and IPC guidelines. According to the findings, healthcare workers aged 31 and up were nearly twice as likely to conduct infection prevention activities than those aged 21–25. As one's educational level rises, so does the practice of infection prevention.

In this study, multiple logistic regression analyses indicated that healthcare workers with a master's degree or higher were four times more likely to engage in infection prevention activities than those with diploma-level qualifications. Similarly, those holding bachelor's degrees were twice as likely to practice infection prevention as their diploma-holding counterparts.

Additionally, healthcare workers with over ten years of work experience demonstrated a greater likelihood of adhering to infection prevention practices than those with less than five years of experience. The data also revealed that healthcare personnel receiving infection prevention training were four times more likely to implement these practices than those not. Access to a steady supply of infection prevention materials increased the likelihood of adherence to these practices. Moreover, healthcare workers who followed infection prevention guidelines were four times more likely to engage in these measures than those who did not.

Table 7

Differences in the Respondents' Knowledge when Grouped according to Sex, Age, Working Department, and Length of Service

Sex					U	p
Mean Ranks for Sample						
Female	Male					
53.1	44.2				847.5	0.17
Age						
Mean Ranks for Sample						
18-25	26-35	36-45	46-55	≥ 56	H	p
24.7	46.8	54.2	59.8	61.3	10.88	0.03*
Working Department						
Mean Ranks for Sample						
OPD	Ward	Lab Rm	ER	Others	H	p
-	59.1	40.8	40.9	46.5	6.53	0.09
Length of Service						
Mean Ranks for Sample						
1-2	3-5	6-10	11-20	≥ 21	H	p
50.6	38.7	49.9	63.3	51.7	6.05	0.20

Table 7 shows no significant difference in the respondents' knowledge of infection prevention and control when grouped according to sex, working department, and length of service. This is exemplified in their respective p values, greater than the margin of error at 0.05. However, the result differs in terms of the respondent's age. Among the age groups, only those 18-25 years old and 36-45 years old significantly differ in favor of the latter. The result shows that respondents 18-25 years old showed a more intense disagreement than those who belong to the age groups of 36-45 years old. Results showed that Sex, with a p-value of 0.17, and Length of service, with a p-value of 0.20, while OPD, with a p-value of 0.09, cannot be included since there are only two ratings.

Desta et al. 's data revealed that healthcare employees aged 31 and over were nearly three times more educated about infection control than those aged 21–25. Male healthcare workers were two times more likely to be

knowledgeable than female healthcare workers. Those healthcare personnel with more than ten years of experience were four times more likely to be knowledgeable about infection control than those with less than five years of experience.

The results in Table 8 indicated no significant differences in respondents' attitudes toward infection prevention and control when analyzed by sex, age, department, and length of service. This conclusion is supported by p-values exceeding the margin of error of 0.05. Specifically, the p-values were 0.70 for sex, 0.35 for age, and 0.77 for length of service. However, data for the OPD department could not be considered, as only two ratings were available.

Table 8

Differences in the Respondents' Attitude when Grouped according to Sex, Age, Working Department, and Length of Service

Sex					U	p
Mean Ranks for Sample						
Female	Male					
49.3	51.7				1065	0.70
Age						
Mean Ranks for Sample						
18-25	26-35	36-45	46-55	≥ 56	H	p
31.5	49.4	56.1	53.9	48.8	4.46	0.35
Working Department						
Mean Ranks for Sample						
OPD	Ward	Lab Rm	ER	Others	H	p
-	52	37.6	45	50.4	2.11	0.55
Length of Service						
Mean Ranks for Sample						
1-2	3-5	6-10	11-20	≥ 21	H	p
48.5	49.7	43.3	56.9	49.4	1.83	0.77

Table 9

Difference in the Respondents' Practices when Grouped according to Sex, Age, Working Department, and Length of Service

Sex					U	p
Mean Ranks for Sample						
Female	Male					
53.2	43.8				835.5	0.14
Age						
Mean Ranks for Sample						
18-25	26-35	36-45	46-55	≥ 56	H	p
35.2	48.8	55.3	53.9	55.1	3.34	0.50
Working Department						
Mean Ranks for Sample						
OPD	Ward	Lab Rm	ER	Others	H	p
-	47.7	43.4	44.3	54.4	2.23	0.53
Length of Service						
Mean Ranks for Sample						
1-2	3-5	6-10	11-20	≥ 21	H	p
42.9	45.4	55.3	63.3	43.9	5.76	0.22

Table 9 showed no significant difference in the respondents' infection prevention and control practices when grouped according to sex, age, working department, and length of service. This is exemplified in their respective p values, greater than the margin of error at 0.05. Results showed that Sex, with a p-value of 0.14; Age, with a p-value of 0.50; and Length of service, with a p-value of 0.22. However, OPD cannot be included since there are only two ratings.

According to Al Ahmari et al., a study in Abha City, Kingdom of Saudi Arabia. About a third of the participants (31.6%) had insufficient understanding of infection control, 88.2% had a positive attitude toward infection control policies and procedures, and 49.5 % had insufficient practice. The result suggests no significant differences in participants' knowledge or attitude according to their socio-demographic characteristics. At the same time, their practices were significantly better among those with a training program about infection control and those with experience <5 years in primary care (p = 0.040 and P = 0.032, respectively).

In another study conducted in Debre Markos Referral, Northwest Ethiopia, more than two-thirds of healthcare staff (84.7%) were knowledgeable, but only 57.3 % of respondents demonstrated good infection prevention practices. Awareness and infection prevention practice were significantly correlated with older age, comprehensive work experience, and higher educational status. The infection prevention practice was also linked to in-service preparation, the availability of infection prevention supplies, and adherence to infection prevention guidelines. Compared to those aged 21–25, healthcare staff aged 31 and up were about three times

more knowledgeable about infection prevention. Male healthcare staff were twice as likely as female healthcare workers to be knowledgeable (Desta et al., 2018).

Conclusion and Recommendations

Infection control programs have been strictly implemented by the Department of Health and the World Health Organization (WHO) in all healthcare facilities over the years to improve healthcare workers' preparedness to respond to threats of outbreaks of highly transmissible infectious diseases and, more importantly, to reduce, if not eliminate, hospital-acquired infections. All healthcare workers in any department must adhere to infection control standards, policies, and procedures. Hospital-acquired infections can be caused by a lack of knowledge, negative attitudes, and inappropriate practices in the prevention and control of infection. Assessing knowledge, attitudes, and practices in infection prevention and control among healthcare workers is crucial to protect both the patient and the healthcare worker. For this, we conducted a study to assess the knowledge, attitude, and practice status of infection prevention and control among healthcare workers to understand better the possible areas for improving infection prevention strategies and practices in Bais and Bindoy District hospitals.

Based on the results obtained, it was evident that the Healthcare workers of Bais and Bindoy District Hospital were knowledgeable in infection prevention and control, with an overall weighted mean score of 1.50. The total mean score for attitude among the respondents was 1.25, indicating a positive attitude towards infection prevention and control. Lastly, the respondents' total mean score for infection prevention and control practices was 1.42, which falls under the category "Good," meaning they have good practices in infection prevention and control.

The study shows a significant relationship between the socio-demographic profile of the respondents and their knowledge and practices on infection prevention and control. The respondents' knowledge of infection prevention was significantly associated with the working department, the availability of personal protective equipment, and the source of information. However, the study also suggests that there was no significant relationship between the socio-demographic profile of the respondents and their attitude toward infection prevention and control.

This study revealed that most professionals do not undergo training courses on infection control, which affects their knowledge and practices

despite a good attitude toward infection prevention and control.

Furthermore, this study shows no significant difference in the respondents' infection prevention and control knowledge, attitude, and practices when grouped by sex, age, length of service, and working department. Among the age groups, only those respondents who belong to the age ranges from 18-25 years old and 36-45 years old significantly differ in favor of the latter.

Even though the respondents have good knowledge, a positive attitude, and high levels of practice in infection prevention and control, good knowledge did not translate into prudent practices. Training on IPC was the independent risk factor towards IPC of attitude and practice. Bais and Bindoy District Hospitals should provide regular and additional on-job and off-job training programs on IPC and strict implementation of updated standard operational procedures (SOP) for all HCWs. PPE and IPC guidelines should always be available for the HCW. Regular and continuing education should be provided, and CPD units should be applied.

Additionally, the IPC audit should include the integration and evaluation of infection prevention and control knowledge, attitudes, and practices of health personnel. The institutions should regularly monitor their employees on the strict implementation of IPC. More studies on KAP regarding Infection Prevention and Control in Negros Oriental are needed. Furthermore, examining the correlation between KAP variables is suggested to provide more precise insights for developing effective strategies.

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References

Al-Ahmari, A. M., AlKhaldi, Y. M., & Al-Asmari, B. A. (2021). Knowledge, attitude, and practice about infection control among primary care professionals in Abha City, Kingdom of Saudi Arabia. *Journal of Family Medicine and Primary Care, 10*, 662-668.

Allegranzi, B. (2011). Report on the burden of endemic healthcare-associated infection: Clean care is safer care. *World Health Organization.* https://www.who.int/infection-prevention/publications/burden

Alwafi, H., Naser, A. Y., Aldaghmi, H., Alzahrani, O. A., Alotaibi, B., & Bahmaid, R. (2021). Infection control compliance among healthcare workers in Saudi Arabia during the COVID-19 pandemic. *Journal of Infection and Public Health, 14*(9), 1167-1173. https://doi.org/10.1016/j.jiph.2021.06.003

Alzghoul, B. I., & Abdullah, N. A. C. (2015). Pain management practices by nurses: An application of the knowledge, attitude, and practices (KAP) model. *Global Journal of Health Science, 8*(6), 154-160. https://doi.org/10.5539/gjhs.v8n6p154

Azuogu, B. N., & Ogah, E. O. (2021). Knowledge, attitude, and practice of infection prevention and control among healthcare workers in southeast Nigeria following a Lassa fever outbreak. *African Journal of Clinical and Experimental Microbiology, 22*(1), 45-52. https://doi.org/10.4314/ajcem.v22i1.7

Chisanga, C. P. (2017). Knowledge, attitudes, and practices of nurses in infection prevention and control within a tertiary hospital in Zambia. *African Journal of Infectious Diseases*, March, 161.

Chris, E. P. (2015). Basic principles of TLC. *Nursing Made Incredibly Easy*, 10(June), 28-37.

Cox, J. L., Simpson, M. D., Letts, W., & Cavanagh, H. M. (2015). Re-thinking microbiology/infection control education to enhance the practice-readiness of health professional students: More than just a curriculum issue. *Journal of Learning Design, 8*(1), 55-67. https://doi.org/10.5204/jld.v8i1.224

Department of Health. (2009). *National standards in infection control for health Philippines.*

Desta, M., Ayenew, T., Sitotaw, N., Tegegne, N., Dires, M., & Getie, M. (2018). Knowledge, practice, and associated factors of infection prevention among healthcare workers in Debre Markos referral hospital, Northwest Ethiopia. *BMC Health Services Research, 18,* 465. https://doi.org/10.1186/s12913-018-3277-5

Gilbert, H. A. (2020). Florence Nightingale's environmental theory and its influence on contemporary infection control. *Collegian, 27*(6), 626-633. https://doi.org/10.1016/j.colegn.2020.09.006

Habboush, Y., Yarrarapu, S. S., & Guzman, N. (2021). *Infection control.* StatPearls Publishing LLC. https://www.ncbi.nlm.nih.gov/books/NBK519017/

Kanu, S., James, P. B., Bah, A. J., Kabba, J. A., Kamara, M. S., Elleanor, C. E., & Kanu, W. J. S. (2021). Healthcare workers' knowledge, attitude, practice, and perceived health facility preparedness regarding COVID-19 in Sierra Leone. *Journal of Multidisciplinary Healthcare, 14*, 67-80. https://doi.org/10.2147/JMDH.S287156

Kretzer, E. K., & Larson, E. L. (1998). Behavioral interventions to improve infection control practices. *American Journal of Infection Control, 26*(3), 245-253. https://doi.org/10.1016/S0196-6553(98)80008-4

Kumar, S., & Kumar, S. (2015). Standard precautions in health care. In *Textbook of Microbiology for BSc Nursing* (pp. 268-268). https://doi.org/10.5005/jp/books/12675_65

Launiala, A. (1970). How much can a KAP survey tell us about people's knowledge, attitudes, and practices? Some observations from medical anthropology research on malaria in pregnancy in Malawi. *Anthropology Matters, 11*(1), 1-11. https://doi.org/10.22582/am.v11i1.31

Lawson, D., McInnes, E., & Haines, M. (2021). The influence of education level and experience on infection prevention and control practices in Australia. *Nursing & Health Sciences, 23*(1), 76-82. https://doi.org/10.1111/nhs.12790

Montaño, D. E. (1992). Health behavior and health education: Theory, research, and practice. *Annals of Internal Medicine, 116*(4), 350. https://doi.org/10.7326/0003-4819-116-4-350_1

Nakano, M., Akiba, T., & Sakamoto, F. (2020). Infection prevention practices and compliance among healthcare workers in emergency departments in Japan. *Journal of Hospital Infection, 105*(4), 589-595. https://doi.org/10.1016/j.jhin.2020.05.013

Ogoina, D., Pondei, K., Adetunji, B., Chima, G., Isichei, C., & Gidado, S. (2015). Knowledge, attitude, and practice of standard precautions of infection control by hospital workers in two tertiary hospitals in Nigeria. *Journal of Infection Prevention, 16*(1), 16-22. https://doi.org/10.1177/1757177414558957

Pittet, D. (2009). *WHO guidelines on hand hygiene in health care: A summary* (1st Global Patient Safety Challenge). World Health Organization. http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf

Rav-Marathe, K., Wan, T. T. H., & Marathe, S. (2016). A systematic review of the KAP-O framework for diabetes education and research. *Medical Research Archives, 4*(1), 1-21.

Reuben, R. C., Danladi, M. M. A., Saleh, D. A., et al. (2020). Knowledge, attitudes, and practices towards COVID-19: An epidemiological survey in North-Central Nigeria. *Journal of Community Health.* https://doi.org/10.1007/s10900-020-00881-1

Sayani, A. (2017). Nightingale's theory and its application. *I-Manager's Journal of Nursing, 7*(2), 38-43.

Spencer, A., Sward, D., & Ward, J. (2010). *Lessons from the pioneers reporting healthcare-associated infections* (ISBN: 9781580246026).

Tien, T. Q., Tuyet-Hanh, T. T., Linh, T. N. Q., Phuc, H. H., & Nhu, H. V. (2021). Knowledge, attitudes, and practices regarding COVID-19 prevention among Vietnamese healthcare workers in 2020. *Health Services Insights, 14*, 1-7. https://doi.org/10.1177/11786329211019225

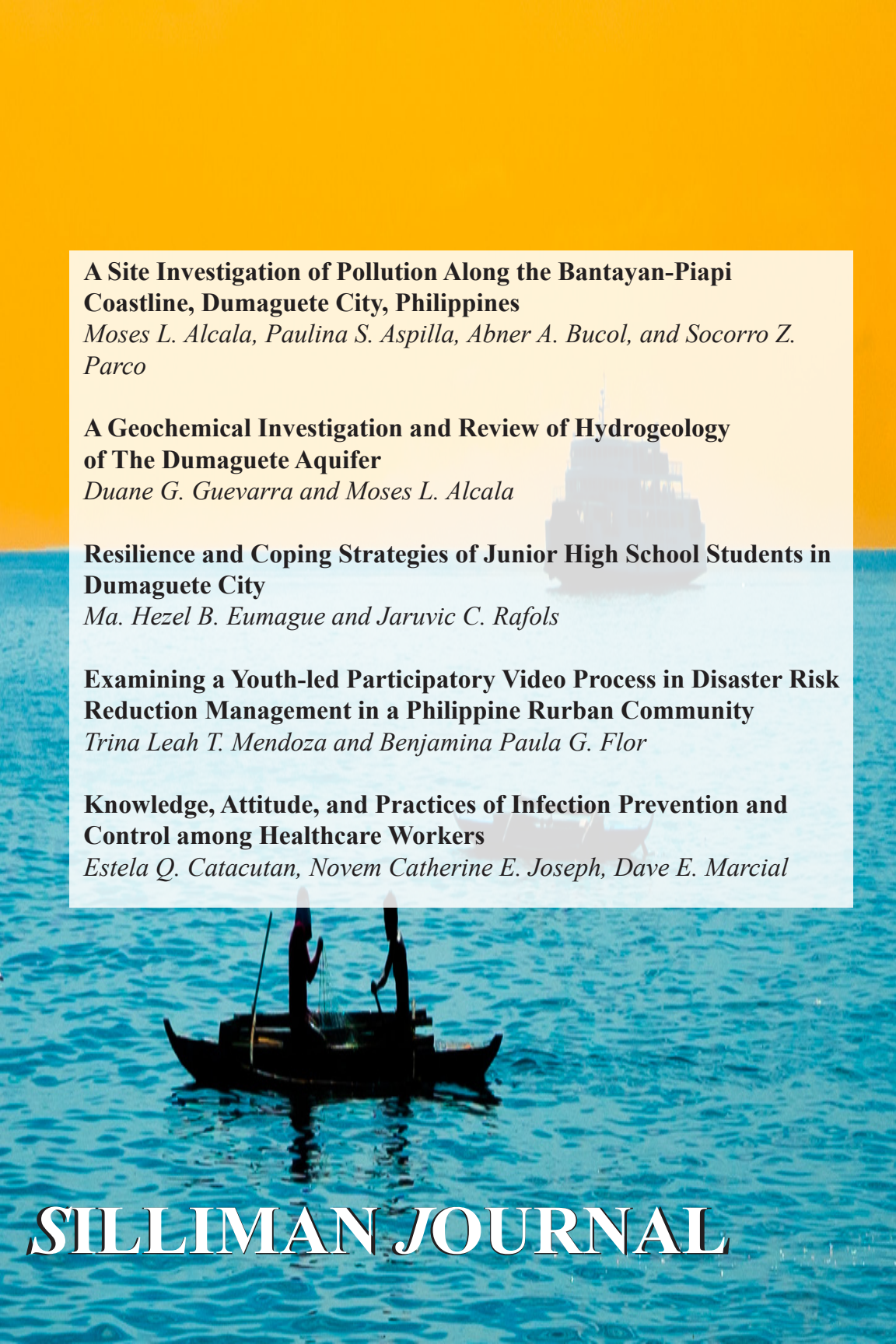
Torraini, F., & Taplitz, R. (2012). History of infection prevention and control. In *Infectious Diseases* (pp. 76-85). https://doi.org/10.1016/B978-0-323-04579-7.00006-X

Unakal, C. G., Nathaniel, A., Keagan, B., Alexandria, B., Lauralee, B., Varun, C., Reneé, D., Sarah, D., Uniqué, T., & Akpaka, P. E. (2017). Assessment of knowledge, attitudes, and practices towards infection prevention among healthcare workers in Trinidad and Tobago. *International Journal of Community Medicine and Public Health, 4*(7), 2240. https://doi.org/10.18203/2394-6040.ijcmph20172813

Vergeire-Dalmacion, G. R., Itable, J. R., & Baja, E. S. (2016). Hospital-acquired infection in public hospital buildings in the Philippines: Is the type of ventilation increasing the risk? *Journal of Infection in Developing Countries, 10*(11), 1236-1242. https://doi.org/10.3855/jidc.8295

Wake, A. (2020). Knowledge, attitude, practice, and associated factors regarding the novel coronavirus disease 2019 (COVID-19) pandemic. *Infection and Drug Resistance.* https://doi.org/10.2147/IDR.S275689

Yakob, E., Lamaro, T., & Henok, A. (2015). Knowledge, attitude, and practice towards infection control measures among Mizan-Aman general hospital workers, Southwest Ethiopia. *Journal of Community Medicine and Health Education, 5,* 370. https://doi.org/10.4172/2161-0711.100037



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