The Efficiency and Social Acceptability of the Constructed Wetland of Bayawan City, Negros Oriental

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The efficiency of constructed wetland becomes an issue in wastewater management because of the investments put into its establishment relative to the benefits it can offer. Of equal importance is the issue of social acceptability because it produces foul odor from the untreated effluents, occupies considerable space, and creates visual impediments in a given place. To deal with these issues, laboratory analyses were conducted revealing that the treated water from the constructed wetland of Bayawan City had significantly improved in terms of physico-chemical qualities as compared to the pre-treated water. The household survey correspondingly supported the laboratory findings as evidently shown in the high social acceptability of the constructed wetland among the residents of Fishermen's Gawad Kalinga Village where this is located. However, it has low social acceptability from the nearby residents and a minority of the GK residents surveyed who can smell the foul odor emitted during the release of the untreated effluents into the treatment pond. This paper concludes that, as a whole, the constructed wetland of Bayawan City rates high in efficiency and social acceptability.

KEYWORDS: wastewater management, constructed wetland, efficiency, social acceptability, domestic effluents, recycled water

INTRODUCTION

The UN millennium development goals (MDG) state that by the year 2015 half of the global population shall have access to basic sanitation that includes the proper disposal of domestic wastewater or effluents. In the Philippines, the Clean Water Act of 2004 (RA 9275) prohibits the dumping of wastewater into the ground as well as discharging it into bodies of water such as creek, river and seas without undergoing treatment processes. The same law mandates all local government units (LGUs) to share in the management and improvement of water quality within their territorial jurisdictions. However, only one percent of the 1,500 cities in the country have domestic and industrial wastewater treatment facilities (UNEP-IETC Report, 2009). Thus, the wider compliance to the provisions of the Clean Water Act remains a vision.

Nevertheless, Bayawan City in southern Negros Oriental in Central Visayas, Philippines has made a difference. In keeping with the MDG on developing global partnership for development and in compliance with the Clean Water Act, PD 856 (Sanitation Code of the Philippines) and RA 6541 (National Building Code of the Philippines), this city invested into a constructed wetland for biologically treating the wastewater from its resettlement housing project with technical assistance from the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) or the German Technical Cooperation Agency (Saraňa, 2008). Constructed wetland (Campbell & Ogden, 1999; Tanner, Nguyen & Suklas, 2005), also called engineered wetland (Huttche, White & Flores, 2002), is one of the methods of ecological sanitation, a relatively new paradigm that views domestic effluents as resources that can be recycled and reused safely rather than being disposed as wastes. It is an artificial marsh or swamp created not only to treat anthropogenic discharges but also to serve as habitat for wildlife (Campbell & Ogden, 1999).

Like a natural wetland that functions as biofilters and removes sediments and pollutants such as heavy metals from the water (Odum, 1971), a constructed wetland (CW) reduces 88% and 90% of phosphate and nitrogen, respectively, of nutrient loads of wastewaters which is highly dependent on the type of constructed wetland and the prevailing form of nitrogen (Kadlec, Tanner, Hally & Gibbs, 2005; Tanner et al., 2005; Vymazal, 2005). Moreover, constructed wetland provides a high removal of inorganic pollutants, suspended solids, heavy metals, parasitic ova and bacterial pathogens, among others (Vymazal, 2005; Masi, n.d.). The dominant nitrogen removal process, commonly observed in mature wetland, is attributed to the denitrification of bacteria in the roots zone while phosphate removal is largely due to nutrient uptake by macrophytes, substratum and biofilm (Odum, 1971; Tanner, 2004; Tanner et al., 2005). The use of vegetation like cattails (*Schoenoplectus tabernaemontani*), common reed and vascular plants known for their nutrient and metal absorption activities (Kadlec et al., 2005, Vymazal, 2005; Siracusa & La Rosa, 2007), helps the constructed wetland to perform the filtering function of a natural wetland.

Bayawan City, which became a chartered city only on December 23, 2000 ventured into a constructed wetland in response to the government's requirement of establishing a wastewater treatment facility for the discharges of the city's resettlement project. It is the first city in the Philippines that utilizes the constructed wetland technology in treating domestic wastewater, built in June 2005 and becoming operational in September 2006. And as wastewater disposal problem becomes inevitable in the future for new cities like Bayawan, with an expected population growth of 2.9% annually (DILG-GTZ, 2008, p. 1), the social acceptability of constructed wetland also becomes a concern particularly because this facility necessarily emits foul odor and occupies considerable space. The investigation of the social acceptability of constructed wetland has to be equally dealt with as the question of its technical efficiency to convert domestic effluents to a reusable resource becomes a priority.

Therefore, this paper evaluates the efficiency of constructed wetland of Bayawan City in treating wastewater and examines its social acceptability among the surrounding residents as it is now operating in order to prove its ecological and social worthiness as an alternative to treatment facilities that are mechanically and chemically operated.

Theoretically, this paper is guided by the principle that ecosystems are interrelated, meaning that the untreated domestic effluents and wastewater being disposed will cause adverse effects to terrestrial and marine life—humans and non-humans alike. The present environmental degradation due to untreated wastewater is a reflection of human apathy towards the importance of this environmental principle. By looking for ways and means to test and promote ecologically-sound waste management practices such as the constructed wetland of Bayawan City, a sustainable way of environmental protection can be promoted and will become widely accepted by the local government units in the country. Dealing with both the issues of efficiency and social acceptability—contrasting domains because the latter is social science in scope while the former is within the field of natural science—is significant because this sends the message that human concerns are of equal importance to the technical effort in environmental protection and management.

METHOD

This is a collaborative research project between researchers of Silliman University—an academe known for its environmental work—and Bayawan City—a local government unit that has successfully established a constructed wetland but has a limited capacity to engage in a systematic investigation regarding how this wastewater treatment facility efficiently works and how the nearby residents feel or react to its establishment and current operation in the community. Nonetheless, this technical deficiency is responded to by the personnel of Bayawan Water District (BAWAD), a local water service provider that has been tapped by the city government to regularly monitor the treated water of the constructed wetland in order to ensure that this is safe for other re-use options. A scientific paper, however, has yet to be written about the constructed wetland of Bayawan City to discover how it has functioned after its establishment.

For this research project, a small grant was provided by Silliman University through the Research and Development Center for the household survey and the laboratory analyses of water samples. Thus the involvement of Silliman University was not during the design and establishment of the constructed wetland but only in the conduct of the efficiency and social acceptability study contained in this paper. Meanwhile, the City Environment and Natural Resources Office (CENRO) of Bayawan City provided the data on the design, operation and maintenance of its constructed wetland. Engineering specifications were noted for the wetland design while plant vegetation were collected and deposited at the Department of Biology of Silliman University as voucher specimen for taxonomic confirmation. Interviews of key personnel for the operation and maintenance of the treatment facility were done along with data verification.

In the efficiency study, the water samples were obtained from the feeder tanks that received the pre-treated wastewater from the resettlement site as well as from the reservoir for final effluent. Ten replicate samples were taken from each site. These samples were analyzed for dissolved oxygen, pH, nitrate, phosphate, total dissolved solids, odor and color. Nutrient samples such as nitrates and phosphates were tested in three pseudoreplicates per replicate. Total coliform count was based on five replicates with two to three pseudoreplicates. The instruments used for water quality determination included spectrophotometer (for nitrate and phosphate determination), pH meter (for water pH determination), Winkler titration (for dissolved oxygen determination), Secchi disk (for color determination of water), and EMB culture medium (for *E. coli* determination).

A quota sample of 90 households were identified through cluster sampling and included in the social acceptability survey with questions covering the functions, benefits and costs, aesthetics, odor emission, and spatial considerations of the facility. The actual respondents were either the husband (23.33%) or the wife (76.67%). These households come from three residential clusters based on varying proximity from the constructed wetland. There were 30 households sampled from each of the clusters. Cluster 1 and 2 are found within the Fishermen's Gawad Kalinga (GK) Village in Barangay Villareal. This is a resettlement site for the affected households of a nearby barangay where the coastal road or boulevard was constructed (See Figure 1). The resettled residents pay a monthly amortization of Php 280.00 for 15 years to the city government with the condition that they cannot resell the unit, if ever, to other parties except to their married children or grandchildren.

Clusters 1 and 2 are located within the 60 meter- and 120 meter-boundary, respectively, from the constructed wetland. The sample households from Cluster 1 and 2 were identified alternately using a random start with an interval of one until the desired sample size was completed for each cluster. Meanwhile, Cluster 3 is composed of households situated within a 30 meter-boundary but scattered outside the GK Village. All 30 households found immediately within the area were surveyed. Although Cluster 3 is not part of GK Village, its inclusion in the sample serves as a control group in the sense that although they are not direct beneficiaries of the wastewater treatment facility, they can smell the foul odor during the release of domestic effluents to the reed bed. Because of this, the Cluster 3 residents were expected to be less inhibited to express their opinions and sentiments, either positive or negative, about the impact of the constructed wetland on their day to day activities.

The data from household survey were treated and analyzed using descriptive statistics such as percentage distribution while the physico-chemical data were treated using t-test to measure the significant differences in the qualities of wastewater before and after they were treated through the constructed wetland. The household survey data and wastewater samples were taken in May 2009 before the onset of heavy rains.

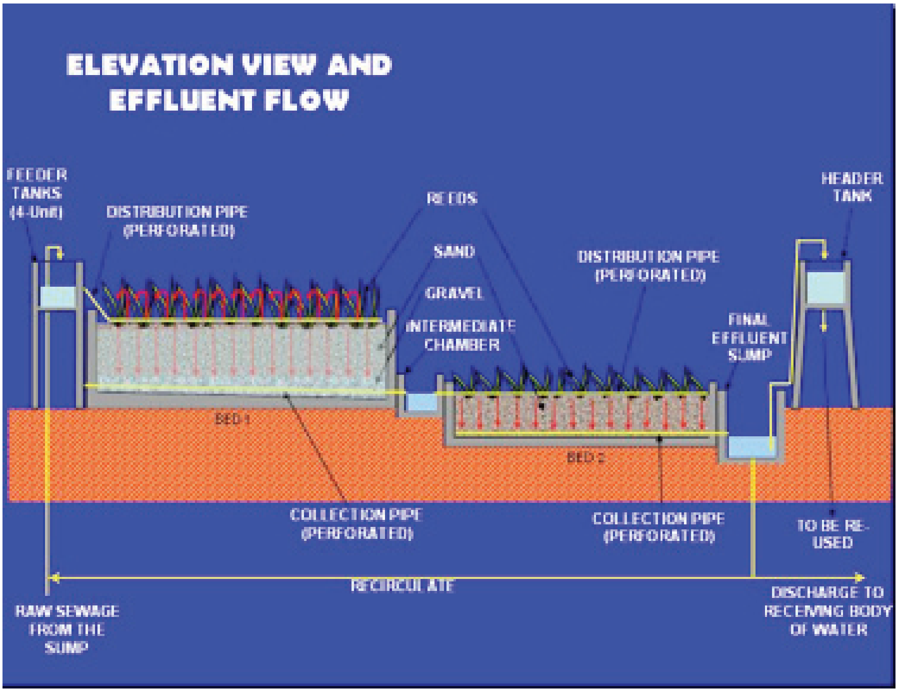

Figure 1. **Diagrammatic components of the constructed wetlands and its effluent flow.** *(Source: City Engineering Office, Bayawan City)*

RESULTS AND DISCUSSION

Design of the constructed wetland. The constructed wetland as a wastewater treatment facility of Bayawan City is a hybrid type that combines two reed bed systems that act as biological filters (See Figure 2). It is a product of the combined effort of a team of international and local or Filipino consultants based in Manila that had "facilitated an intensive knowledge exchange and the introduction of the vertical soil filter as a new technology option in the Philippines" (DILG-GTZ, 2008, p. 3). But, more importantly, "the inventiveness of the City Engineering staff of *Bayawan* and the responsiveness of the consultants made it possible to continuously adjust the design to suit local conditions" (ibid., *emphasis added*). Thus, the city government was able to achieve a facility that is affordable and reliable to treat wastewater that can eventually produce safe water for different re-use options.

The constructed wetland is strategically situated within the GK Village along the shoreline that is now part of its coastal road (popularly called by locals as *Boulevard*). It is made up of vertical flow (VF) and horizontal flow (HF) systems arranged in two stages. The combined area of the facility is 2,700 square meters that served 670 households (as of the period of the survey) in a 7.4 hectare housing project. The rated capacity of the constructed wetland is 180 m3 which can be filled up three times a day. The reed bed has a depth of 0.75 meter that is made up of 0.6 meter of sand, 0.05 meter of pea size gravel and 0.1 meter of gravel. The vegetation that is used as filtering medium is *Phragmites karka*, an indigenous and abundant plant in the locality called *tambo* with a root system that penetrates to the whole bed.

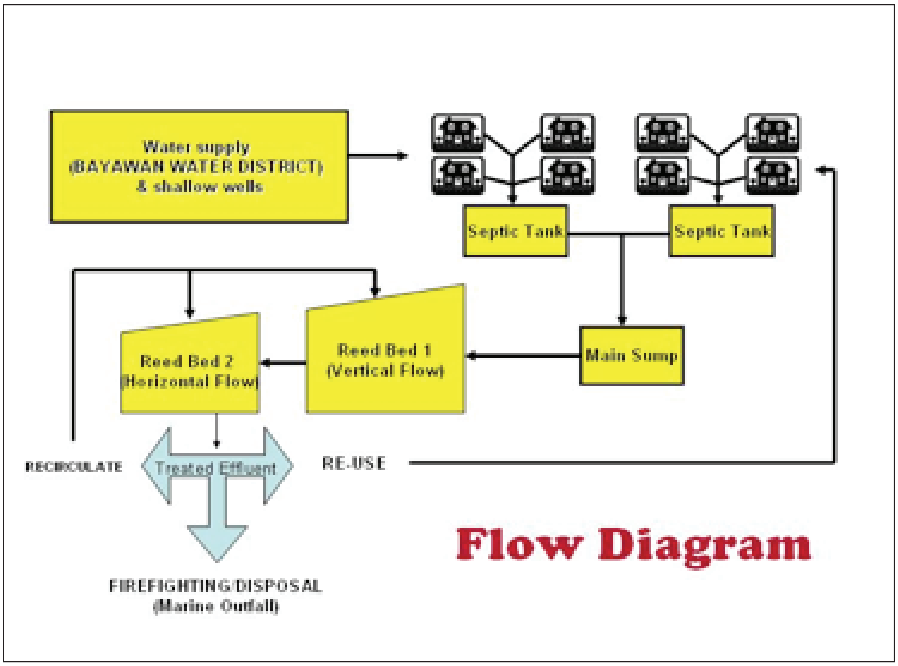

Figure 2. **Diagram flow of water from source to septic tank then to the wastewater treatment facility.** *(Source: City Engineering Office, Bayawan City)*

The wastewater from the toilets as well as the bathroom and kitchen sinks from the houses of GK Village is drained in a three-chambered septic tank. The overflow from these tanks is expected to be low in solids that will then be transported through a sewer system to the main sump for storage and settling of remaining solids. From the main sump, the wastewater is pumped into four feeder tanks and later flowed into a vertical type of reed bed. The wastewater is distributed through a series of 12 perforated pipes that eject the wastewater into the air before vertically seeping into the filter bed; hence, it is called vertical flow (VF) type of wetland. From the first reed bed, the water flows into the second reed bed by gravity. Because only a singular distribution pipe is used to distribute the water horizontally before the wastewater seeps into the filter bed, this section is described as horizontal flow (HF) wetland. Conventionally, VF constructed wetland provides a good condition for nitrification but poor denitritifcation while HF constructed wetland provides high removal of organic and suspended solids. Combining the two systems in a staged manner will provide optimal water purification processes as shown in hybrid CWs from five countries (Vymazal, 2005).

The daily operation of the constructed wetlands requires the filling-up of the feeder tanks with wastewater in the morning. Its release to the reed bed takes place at night until early morning but the time varies depending on the northeast and southwest monsoons that influence wind direction that carries the foul odor from the feeder tanks. During the northeast monsoon (from November to April), locally known as *amihan*, the wastewater from the feeder tanks is released as early as 8 in the evening because the wind direction is toward the seas. However, during the southwest monsoon (from May to October) or *habagat*, the wastewater is released between 10 to 11 o'clock in the evening because the wind moves toward the residential areas. The operation is divided into three shifts of work schedule: 7 a.m. to 3 p.m., 3 p.m. to 11 p.m. and 11 p.m. to 7 a.m., respectively. The maintenance activities include pipe flushing, sump cleaning in the pretreatment and treatment collection systems, tank brushing, repainting, reed grass planting, harvesting and replanting. Regular activities also require inspection and repair of electrical lines, pumps and equipment.

In principle, the constructed wetland as a wastewater treatment facility cleans dirty or contaminated water by filtering it through the soil and the root zone of the reeds that are filled with aerobic and anaerobic bacteria that are known to decompose organic and inorganic materials (Vymazal, 2005). The treated wastewater is then directed into a collecting sump that will then be pumped into the header tank for storage or reusing in construction work, irrigation, fire fighting and home gardening. As to the sludge from the septic tanks, a biogas digester or reactor and soil filter will process it to biofertilizer and methane. This wastewater treatment facility is now a part or component of the on-going construction of the sanitary landfill project of the city government.

The total cost in the construction of the wetland was about PhP10 million, including consultancy fees and labor cost (DILG-GTZ, 2008, p. 2). The amount came from the loan of the city government of Bayawan. And based on the record since the operation of the constructed wetland, the cost for operation and maintenance is computed to be about PhP33,000 per month, covering salaries and wages for four personnel as well as for repair work. The monthly cost of electricity for the pumping operation is PhP700. Meanwhile, a yearly budget of about PhP400,000 is allocated for the over-all operation and maintenance of the constructed wetland. A cost-benefit analysis of the constructed wetland is deemed necessary in future research to demonstrate its cost effectiveness to other LGUs. (More information about the project history, design, technical operation and maintenance of the constructed wetland of Bayawan City is available at http://www.watsansolid.org.ph.)

Physico-chemical indicators of efficiency. The physical and chemical parameters of the treated wastewater show significant improvement when compared to the untreated wastewater. Specifically, the constructed wetland is able to improve total dissolved solids by 54%, dissolved oxygen from 0 mg/L to 6.25 mg/L, phosphate by 62%, and biological oxygen demand (BOD) after five days by 99%. The color and odor of wastewater greatly improved from dark gray and noxious into colorless and odorless, respectively. The total coliform count is reduced by 71%.

Meanwhile, the increase of nitrate in the treated wastewater is expected because its precursor form which is *ammonium* (NH4) takes a certain time period before it can be converted into nitrate, the most oxidized form of nitrogen (Molles, 1999; Vymazal, 2005). However, in agricultural run-offs that get into wastewater treatment facility, it is observed that nitrate levels are already very high in the untreated wastewater compared to the treated wastewater. This is because nitrogen fertilizers in agricultural systems are already in the form of nitrate. In domestic waters, nitrogen compounds are in the form of ammonium as a result of bacterial action during decomposition (Vymazal, 2005).

Table 1.

Efficiency Table of the Constructed Wetland in Wastewater Treatment.

Parameters	Untreated Water	Treated Water	Efficiency Rating	Sample Size (N)	DENR Standard* (Water Class)
Total Dissolved Solids (gram/L)	0.054	0.025	53.70%	20	0.5 (AA)
Oxygen (mg/L)	0.00	6.25	NA	20	5 (AA)
Phosphate-P (mg/L)	40.90	15.52	62.05%	20	0.1 (A)
Nitrate-N (mg/L)	0.01	3.01	NA	20	10 (A)
BOD (mg/L)**	138	0.92	99.33%	24	1 (AA)
Total Coliform (CFU/mL)	33,566	9,733	71.00%	10	1000 mpn/100ml (A)
pH	7.05	7.18	NA	20	6.5-8.5 (AA)
Temperature	29.63	29.10	NA	20	Not more than 3^{o} C rise (AA)
Color	Dark gray	Clear	NA	20	No abnormal discoloration
Odor	Noxious	Odorless	NA	20	Odorless

*DAO 34, Series of 1990
** BOD data was collected by Jonah Butler, a Fulbright-Hayes scholar, who was working on his Masters thesis. The data are used here with his permission.
NA(not applicable), AA (public water supply class I), A (public water supply class II)

The succeeding discussions tell the specific analysis and the results of the test of difference in the parameters being measured before and after the effluents passed through the constructed wetland.

Total dissolved solids. The average total dissolved solid (TDS) from the untreated wastewater of GK Village was 0.054 grams/L with a standard deviation of ± 0.015 grams/L. After passing through the treatment facility, the total dissolved solids decreased to an average of 0.024 grams/L with a standard deviation of ± 0.009 grams/L. This value is a reduction of 54 % from the total dissolved solid value of the untreated wastewater. Furthermore, there is a significant difference of the total dissolved solids between untreated and treated wastewaters (t computed value = 5.18; t critical value = 2.10; p = 0.000063: *See Appendix A*).

The TDS of the treated wastewater is lower than the Department of Environment and Natural Resources (DENR) standard of 0.5 g/L (*Refer to Table 1*). The observed low dissolved solids value is attributed to the strict adherence of the residents to the community guideline on non-inclusion of solid waste in their wastewater. This is further enhanced by the 3-chambered septic tank design for each household, thus, ensuring that solid particles are settled in these chambers. As a cursory data, untreated wastewater had the appearance of dark grey color while the treated wastewater was clear.

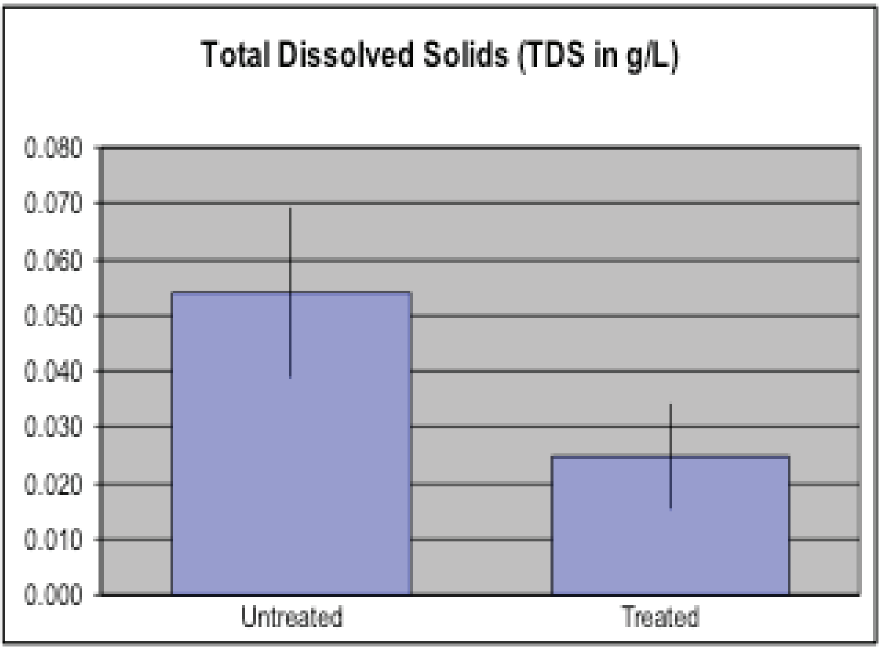

Figure 3. **Total dissolved solids in untreated and treated wastewater.**

Water temperature. There is a significant difference of the water temperature between the untreated and treated wastewater (t computed value = 14.45; t critical value = 2.10; p = 0.000: *See Appendix B*). The average temperature of the untreated wastewater was 29.63°C with a standard deviation of + 0.12 while treated wastewater had an average temperature of 29.10°C and a standard deviation of 0. Compared to DENR standards, the water temperature is within the normal range which is measured in terms of degrees Celsius fluctuation of not more than three (*Refer to Table 1*).

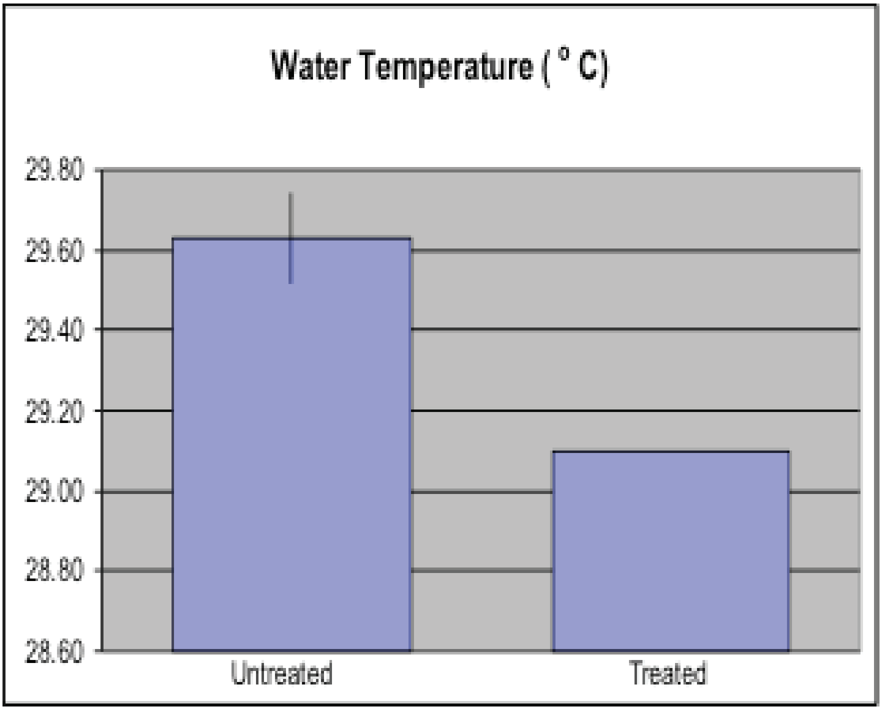

Figure 4. **Water temperature in untreated and treated wastewater.**

Water pH. In the untreated wastewater, the average pH was 7.05 with a standard deviation of ± 0.13 which is lower if compared with the treated wastewater which has an average pH of 7.18 and a standard deviation of + 0.14. The statistical test shows that there is a significant difference in the water pH between untreated and treated wastewaters (t computed value = 2.23; t critical value = 2.10; p = 0.038: *See Appendix C*). Water pH is within the standard range from 6.5 to 8.5 as set by the DENR (*Refer to Table 1*).

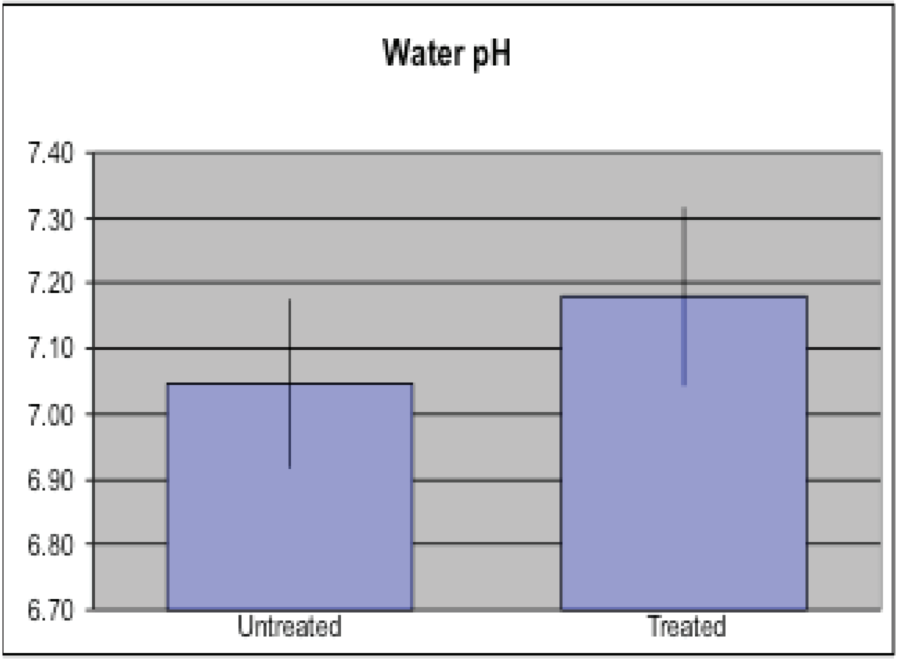

Figure 5. **Water pH in untreated and treated wastewater.**

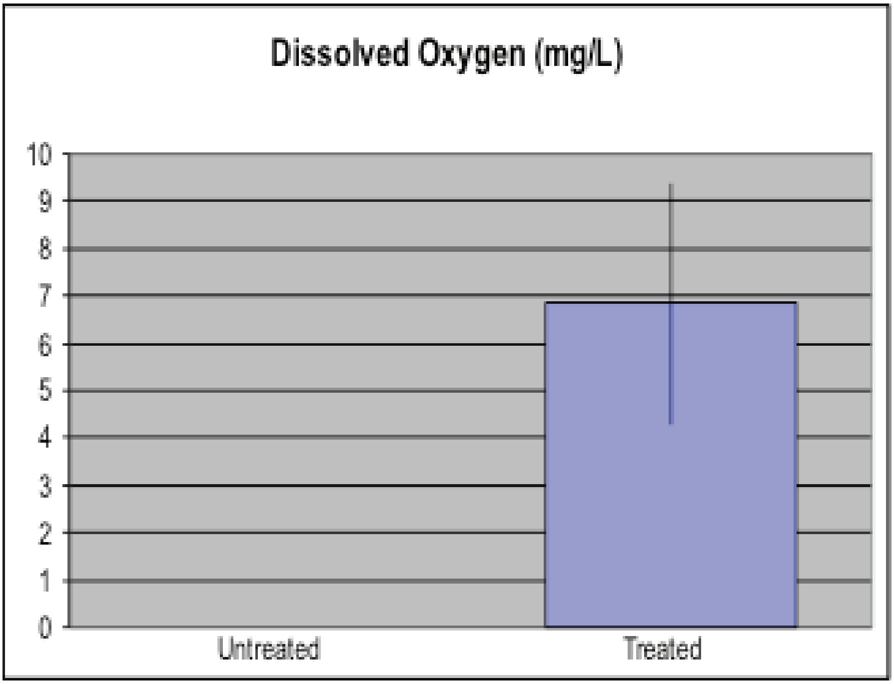

Figure 6. **Dissolved oxygen in untreated and treated wastewater.**

Dissolved oxygen. There is also a significant difference in the dissolved oxygen between untreated and treated wastewater (t computed value = 8.47; t critical value = 2.10; p = 0.000: *See Appendix D*). The laboratory analysis shows that the average dissolved oxygen of the untreated wastewater was 0 mg/L. In contrast, the dissolved oxygen of the treated wastewater was 6.84 mg/L with a standard deviation of + 2.55 mg/L).

The oxygen level of the treated wastewater exceeded the DENR standard of 5 mg/L (*Refer to Table 1*). There are two possible sources of oxygenation in this kind of constructed wetland, namely: the hollow, air-filled channels of the roots and rhizomes that are connected to the atmosphere (Vymazal, 2005) and the natural aeration process of the wastewater in the vertical flow system of the reed bed.

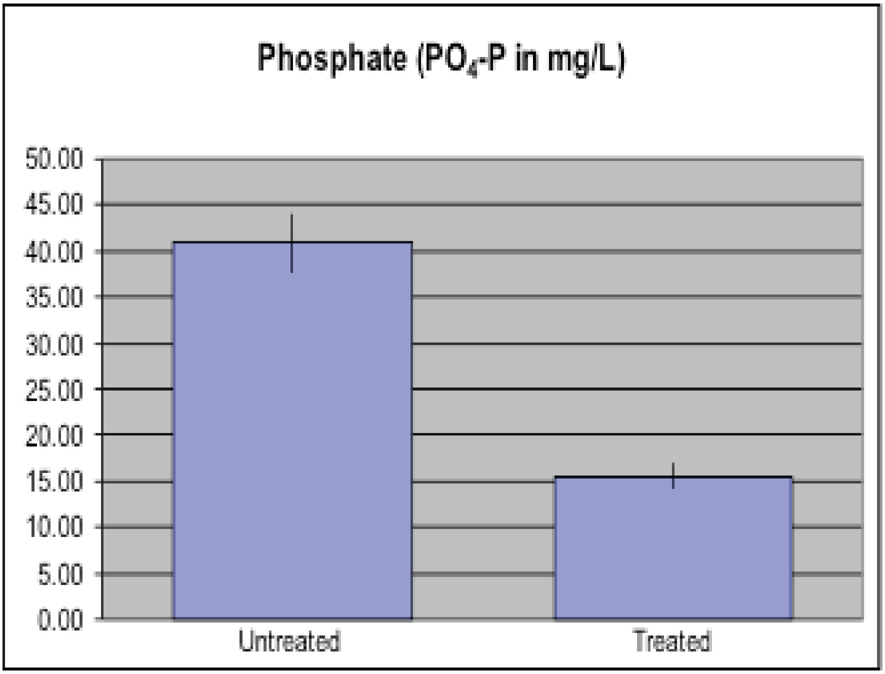

Figure 7. **Phosphate-P in untreated and treated wastewater.**

Phosphate and nitrate contents. There is a significant difference in the phosphate content between untreated and treated wastewaters (t computed value = 22.32; t critical value = 2.10; p = 0.000: See Appendix E).The average phosphate content of the untreated wastewater was 40.90 mg of PO4-P/L while the treated wastewater showed an average of 15.52 mg of PO4-P/L. This figure represents a 62% reduction from the original phosphate content of the untreated wastewater.

However, this value is still high when compared to the DENR standard of 0.1 mg of PO4-P/L of water. But this level of phosphate is comparable to the study of Vymazal (2001 as cited in Vymazal, 2005) of treated wastewater of constructed wetlands in several countries and this suggests that the case of Bayawan City is within the norm of similar facilities elsewhere.

On the other hand, the average nitrate content of the untreated wastewater was 0.01 mg of NO3-N/L. In comparison, the treated wastewater shows an average of 3.01 mg of NO3-N/L. And statistically, there is also a significant difference of the nitrate content between untreated and treated wastewaters (t computed value = 7.09; t critical value = 2.10; p = 0.000: *See Appendix F*). As a cursory data, it was observed that the untreated wastewater was characterized by a heavy noxious ammonia-like smell.

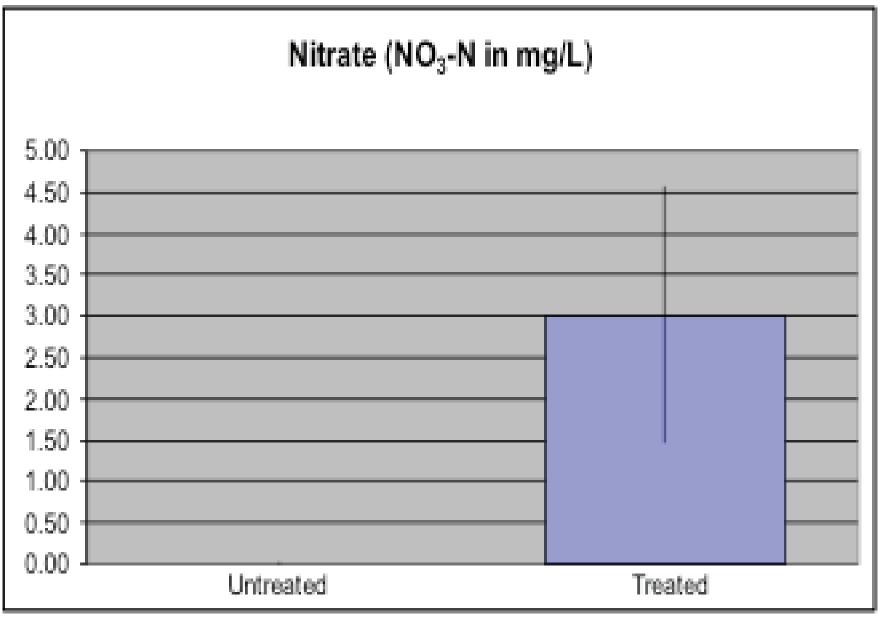

Figure 8. **Nitrate level of untreated and treated wastewater.**

Coliform count. The average total coliform count of the untreated wastewater was 33,566 CFU/mL with a standard deviation of ± 19,000 while the treated wastewater showed an average of 9,733 CFU/ mL with a standard deviation of ± 10,000. This number indicates a reduction of 71%. Statistically, there is a significant difference in the total coliform count between untreated and treated wastewaters (t computed value = 2.45; t critical value = 1.86; p = 0.039: *See Appendix G*). However, the level of *E. coli* in the treated water is still high as compared to the DENR standard of 1,000 mpn /100 mL (*Table 1*) that requires complete disinfection treatment to meet the standards for drinking water (DAO 34, series of 1990).

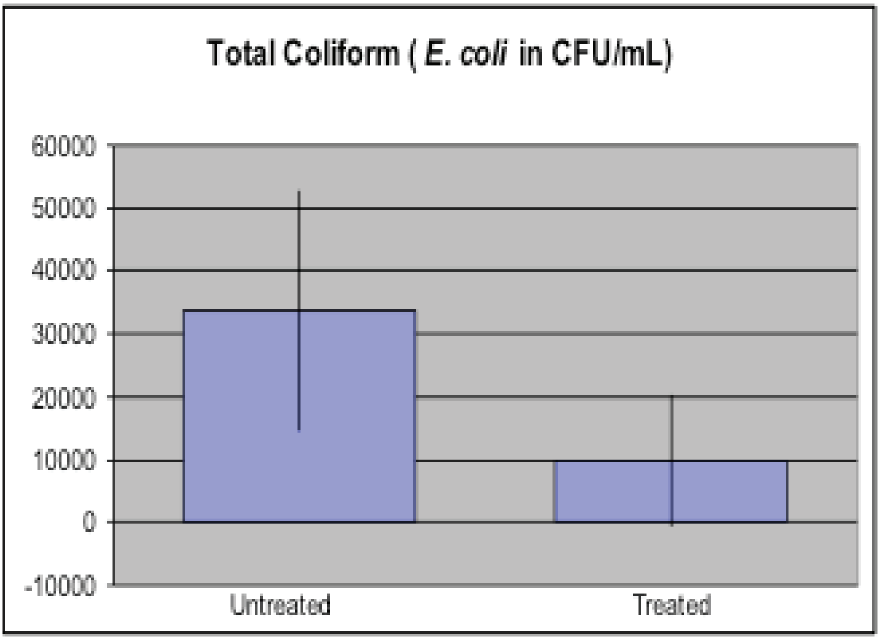

Figure 9. **Total coliform count (in colony forming units/mL).**

Community's understanding about the constructed wetland. A review of documents shows that the constructed wetland of Bayawan City has an environmental compliance certificate (ECC) with the number 07040802-0366212. Community consultation is part of the process of getting an ECC prior to the establishment of a wastewater treatment facility or any construction work that impacts the community (DAO 21, s. 1992; DAO 37. s.1997). A forum was held for the project proponent, regulatory agency, and stakeholders to communicate and share information about concerns and issues regarding the facility. In the case of the constructed wetland, the household survey data show that 54% of the total respondents were not aware of such community consultation regarding its establishment (*See Table 2a*).

Nevertheless, most of the residents within the GK Village were aware that community consultation had taken place. These residents, particularly in Cluster 2, were those who were resettled when the facility was being constructed. The data show that 73% of Cluster 2 residents said they were consulted compared to 47% of Cluster 1 residents.

The contrasting responses among GK residents were clarified when the respondents from Cluster 1 said that the constructed wetland was already built when they were resettled there, hence, there was no way for them to be part of the consultation. Meanwhile, 86% of Cluster 3 residents said they were not aware of the community consultation because they are residents outside of the GK village where the facility is directly situated. Although there were consultation meetings held to discuss the establishment of the wetland, 58% of the total respondents admitted that they had not attended any of these. These respondents come particularly from Cluster 1 (56.67%) and 3 (96.67%). Among Cluster 2 residents, 80% had attended while 20% did not attend (*See Table 2b*).

After having understood the functions of the constructed wetland, 46% of the total respondents agreed with its establishment. Only 32% did not agree with it while 22% did not know much about its functions, hence, did not express specific position on the matter. Majority of those who claimed that they did not know were Cluster 3 residents (See Table 2c). Those who had positive responses explained that the constructed wetland cleanses their domestic waste water and protects the seas from pollutants. Those with negative stance said that it has foul odor during the operation and that the treated waste water still contains high level of bacteria.

Table 2.

Awareness, Consultation Attendance, and Agreement About the Constructed Wetland.

	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Total (%)
A. If Aware of Community Consultation				
Yes	14 (46.67)	22 (73.34)	4 (13.33)	40 (44.44)
No	16 (53.33)	7 (23.33)	26 (86.67)	49 (54.45)
Do not know		1 (3.33)		1 (1.11)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)

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	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Total (%)
B. If Had Attended Consultation				
Yes	12 (40.00)	24 (80.00)	1 (3.33)	37 (41.11)
No	17 (56.67)	6 (20.00)	29 (96.67)	52 (57.78)
Do not know	1 (3.33)			1 (1.11)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)
C. If Had Agreed Its Establishment				
Yes	14 (46.67)	22 (73.33)	5 (16.67)	41 (45.56)
No	15 (50.00)	5 (16.67)	9 (30.00)	29 (32.22)
Do not know	1 (3.33)	3 (10.00)	16 (53.33)	20 (22.22)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)

Functions and benefits. The top three of the functions of the constructed wetlands known to all the respondents include cleaning of domestic wastewater (32.22%), recycling of water for washing (23.34%) and watering of plants (13.33%). Although by location Cluster 3 is outside the GK Village, 67% of the respondents think that the constructed wetland functions for the treatment of domestic wastewater compared to the other clusters. The residents of Cluster 1 equally perceive the facility to be effective for treating domestic wastewater that can be used for watering the plants (30.00%). Meanwhile, Cluster 2 residents consider the treated wastewater for washing (43.44%). As a whole, 24% of all the respondents do not exactly know the functions or importance of the constructed wetland for their households or the community.

Table 3.

Functions of the Constructed Wetland Known to the Respondents.

Functions	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Total (%)
Treats or cleans domestic wastewater	9 (30.00)		20 (66.67)	29 (32.22)
Recycles water for washing	5 (16.66)	13 (43.34)	3 (10.00)	21 (23.34)

Continued...

Functions	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Total (%)
Provides treated water for plants	9 (30.00)	1 (3.33)	2 (6.66)	12 (13.33)
Serves as repository of dirty water	3 (10.00)			3 (3.33)
Benefits the community	2 (6.67)			2 (2.22)
Helps during scarcity of water		1 (3.33)		1 (1.11)
Do not know about functions	2 (6.67)	15 (50.00)	5 (16.67)	22 (24.45)
Total	**30 (100.00)**	**30 (100.00)**	**30(100.00)**	**90(100.00)**

But despite some negative reactions about the constructed wetland, 70% of all the respondents agree that this provides benefits to the community in terms of recycled wastewater. Only 21% do not see its benefits because of its foul odor while 9% say that they do not know about its benefits (*see Table 4a*). Moreover, 57% agree that the constructed wetland functions effectively but this figure refers only to the residents of Cluster 1 (90.00%) and 2 (63.34%). Meanwhile, 57% of the Cluster 3 residents do not agree because, according to them, the treated wastewater is still not potable and it produces foul odor during the treatment process (*Table 4b*).

This sentiment would explain why the Cluster 3 residents are divided about whether or not the location of the constructed wetland is perfect for it. Nevertheless, 66% of all the respondents agree that it is perfectly located (*Table 4c*). They explain that its location allows it to immediately get the wastewater and effluents from the resettlement sites and enhances the view of the village. Meanwhile, those who disagree persistently argue that it produces foul odor and should be located far from the residential areas.

Table 4.

On the Benefits, Functions and Location of the Constructed Wetland.

	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Total (%)
A. If Agreeable About Benefits				
Yes	29 (96.67)	16 (53.33)	18 (60.00)	63 (70.00)
No	1 (3.33)	12 (40.00)	6 (20.00)	19 (21.11)
Do not know		2 (6.67)	6 (20.00)	8 (8.89)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)
B. If Agreeable About Functions				
Yes	27 (90.00)	19 (63.34)	5 (16.66)	51 (56.67)
No	3 (10.00)	10 (33.33)	17 (56.67)	30 (33.33)
Do not know		1 (3.33)	8 (26.66)	9 (10.00)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)
C. If Agreeable About Location				
Yes	26 (86.67)	20 (66.67)	13 (43.33)	59 (65.56)
No	4 (13.33)	10 (33.33)	13 (43.33)	27 (30.00)
Do not know			4 (13.34)	4 (4.44)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)

Correspondingly, 51% of the respondents agree that the treatment facility is worthy of the investment of the local government. They explain that it gives greater benefits in treating wastewater and in providing proper drainage system for the entire GK village. Again, the emission of foul odor is pointed out by nine percent of the respondents to be the reason why it is not worthy of the investment. Meanwhile, 40% of the respondents, particularly from Cluster 3, admit that they do not know if the facility is worthy of the investment because they have no idea of its construction cost (*Table 5a*).

Meanwhile, 63% of the total respondents agree about the establishment of several other constructed wetlands in Bayawan City (*Table 5b*). Among the reasons they have are the following: cleans domestic wastewater, provides benefits to the community in terms of recycled water, and prevents clogging of drainage. But they also express a common concern regarding the foul odor that comes from the treatment facility during their operations. They hope that this could be effectively addressed. And although they agree about having more wetland to be constructed, 82% disagree or are unwilling to pay user's fees for the operation of the facility because it is an additional expense on their part. They also argue that it should be part of the responsibility of the local government. Only about nine percent are willing to pay it (*Table 5c*). It is going to be a big challenge for the government to convince residents to shoulder a part of the cost of having a clean environment.

Table 5.

On the Issue of Investment, Construction of More Wetlands and Willingness to Pay.

	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Total (%)
A. If Agreeable About Investment				
Yes	23 (76.67)	19 (63.33)	4 (13.33)	46 (51.11)
No	1 (3.33)	5 (16.67)	2 (6.67)	8 (8.89)
Do not know	6 (20.00)	6 (20.00)	24 (80.00)	36 (40.00)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)
B. If Agreeable About Building More				
Yes	24 (80.00)	19 (63.33)	14 (46.67)	57 (63.33)
No	4 (13.33)	6 (20.00)	9 (30.00)	19 (21.11)
Do not know	2 (6.67)	5 (16.67)	7 (23.33)	14 (15.56)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)
C. If Agreeable About User's Fees				
Yes	4 (13.33)	4 (13.33)		8 (8.89)
No	25 (83.33)	25 (83.33)	24 (80.00)	74 (82.22)
Do not know	1 (3.33)	1 (3.33)	6 (20.00)	8 (8.89)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)

Odor and aesthetics. In order to resolve further the matter on odor and aesthetics of the constructed wetland, the respondents were asked to agree or disagree with statements that qualify the extent of the foul odor and visual impediments that this facility has created or brought to the surrounding residents. The data show that they are divided as to the degree of foul odor that reaches their respective area. Across the three clusters, 39% of the respondents say that the facility does not produce any foul odor, 37% say that the facility produces tolerable odor at certain times, 24% of them indicate that the facility produces unbearable odor all the time. When examined per cluster, 87% of Cluster 2 residents say that the constructed wetland does not produce foul odor. Cluster 1 respondents indicate that the facility produces tolerable odor at certain times while Cluster 3 respondents answer that the facility produces unbearable odor all the time (*Table 6a*).

These foregoing answers suggest that the closer the cluster to the constructed wetland, the greater is the degree of complaints against the foul odor that is normally associated with domestic waste water treatment facility. In this case, the most affected cluster among the three clusters is Cluster 3 which is within the 30 meter radius from the treatment facility. This is followed by Cluster 1 which is located within the 60 to 90 meter radius from the treatment facility and Cluster 2 which is located within the 120 to150 meter radius from the facility.

Despite the foul odor as one of the major issues among the respondents, 57% of the total respondents think that the constructed wetland is an added attraction to the community (*Table 6b*). Thirty-three percent who remark that the facility is somehow an eyesore to the community mostly come from Cluster 2 (60.00%). Meanwhile, 10% really feel that it is an eyesore. And among the three clusters, Cluster 1 and 3 respondents (93% and 43%, respectively) indicate that the treatment facility is an added attraction to the community because these are the residents whose houses are located near the treatment facility. Their proximity to the constructed wetlands allows them to directly observe the visitors of the treatment facility. Currently, Bayawan City has been visited by environmentalists from the academe, non-government organizations, and government agencies because of the increasing popularity of its constructed wetland.

Table 6.

Responses to Statements About Odor and Aesthetics of the Constructed Wetland.

	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Total (%)
A. On the Issue About Foul Odor From the Constructed Wetland				
The wetland or waste water treatment facility does not produce foul odor at any time.	1 (3.33)	26 (86.67)	8 (26.67)	35 (38.89)
The wetland or waste water treatment facility produces tolerable odor at certain time.	26 (86.67)	3 (10.00)	4 (13.33)	33 (36.67)
The wetland or waste water treatment facility produces unbearable odor all the time.	3 (10.00)	1 (3.33)	18 (60.00)	22 (24.44)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)
B. On the Issue About the Aesthetics of the Constructed Wetland				
The wetland or wastewater treatment facility is an added attraction to the community.	28 93.34)	10 (33.33)	13 (43.33)	51 (56.67)
The wetland or wastewater treatment facility is somehow an eyesore to the community.	1 (3.33)	18 (60.00)	11 (36.67)	30 (33.33)
The wetland or wastewater treatment facility is an eyesore to the community.	1 (3.33)	2 (6.67)	6 (20.00)	9 (10.00)
Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)

CONCLUSIONS AND RECOMMENDATIONS

The level of social acceptability of the constructed wetland by the residents of the GK Village is seemingly high as compared to those residing outside the resettlement site but near the facility. This favorable sentiment is expressed in the agreement of the GK residents to the following issues: reasons for its establishment, effectiveness in its functioning, benefits to the community, appropriateness of location, worthiness of the investment, and establishment of more engineered wetlands. However, they do not accept the idea about requiring the residents to pay for using the facility.

The major issue that has created negative sentiments to a minority of the GK residents and a majority of the outside residents is the foul odor that the facility produces every time the wastewater and effluents are released to the treatment area. To mitigate this problem, the facility management releases the untreated wastewater to the reed bed at night when everyone is asleep or depending on the onset of the northeast and southwest monsoon. Also, the regular cutting of the reeds as part of the maintenance work to ensure the efficiency of the constructed wetland is done at gradual phases in order to maintain some standing reeds as wind buffers.

The perceived effectiveness in the functioning of the constructed wetland benefits the GK Village residents by providing them treated wastewater for watering their plants as well as the city government by providing the same for watering its ornamental plants in the center islands of the coastal roads and for fire truck refilling, reinforcing the results of the analysis of untreated and treated water samples from the facility. The laboratory results show a significant improvement in wastewater quality after being treated using the constructed wetland as a biological treatment facility. Marked changes in treated water were recorded for total dissolved solids, dissolved phosphate, BOD, total coliform, color, and odor. The cost for establishing a constructed wetland may be high for now but its proven efficiency to treat and recycle wastewater in the long run makes it economically wise when water for domestic and agricultural uses becomes a scarce commodity during droughts due to climate change.

In order to further enhance and sustain the efficiency and social acceptability as well as the adoption of the constructed wetland technology of Bayawan City by other agencies and institutions, the following recommendations have to be considered in future plans of actions:

1. Residents are aware that E. coli is present in the treated wastewater. This was made known to them from previous water analyses and has discouraged them to re-use treated wastewater. It is suggested that appropriate technologies that will lower E. coli levels be explored. Possible studies may include exposure of treated wastewater to intense sunlight and the application of agricultural lime in lieu of hydrated lime. Along with the lowering of E. coli levels, watering techniques for food crops using the treated wastewater should be explored as well to avoid bacteria contamination.

2. There is a high potential of treated wastewater as an alternative form of bio-fertilizer. Phosphate and nitrate content in the treated wastewater are nutrients that can be used to substitute commercial fertilizers, thus will entail monetary savings for the household in general.

3. The negative perception by residents of community consultation, fees for wastewater treatment, and the foul odor during the operation of the treatment facility are learning points for any local government units that plan to build a similar facility. Public awareness through regular community dialogues should be encouraged. The planting of aromatic vegetation such as ilang-ilang (Cananga odorata), dama de noche (Cestrum nocturnum), rosal (Gardenia jasminoides), camia (Hedychium philippenense) and kalachuchi (Plumeria acuminata) near the treatment facility is recommended to help counteract the foul odor emitted every time the wastewater is released at night. How this vegetation will work in preventing or reducing foul odor has to be systematically studied.

4. There should be continuing information, education and communication drives on the part of the local government unit about research results and improvements in the functioning of the constructed wetland in order to improve the perceptions of and relationships with various stakeholders.

5. It is also encouraged that a regular pulong-pulong or meeting among residents be held in order to open up troubling issues and to generate ideas that would help solve possible conflicts in the management and operation of the constructed wetland. This may lead to a community-based management plan where ideas for the

improvement of GK Village can start.

6. The establishment of an LGU-based water laboratory and capacitating its personnel are important future undertakings on the part of Bayawan City. This will ensure that there is continuity in monitoring and sustaining the efficiency of the constructed wetlands. It can also be a source of services that the LGU can offer for fees to other municipalities and cities that are not equipped with this technical knowledge.

7. Finally, the constructed wetland is not only intended for local government units to go into, particularly that it has already a tested efficiency, but also to developers of gated communities or subdivisions. It should be remembered that housing projects are required to treat their wastewater prior to its discharge to bodies of water. The treated water could also have several other uses such as for firefighting and watering of ornamental plants in gated communities. Colleges and universities with enough space can also consider setting up their own constructed wetland to treat their wastewater.

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