# A Study of some Chemical Parameters of the Balinsasayao and Danao twin lakes, Sibulan, Negros Oriental

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**Abstract.** The levels of dissolved oxygen, biochemical oxygen demand, nitrate, phosphate, chloride, and pH were measured in two lakes in Negros Oriental. The reasons for the variations in the levels are discussed. The high level of nitrates and phosphate have led to algal growths. The construction of a road near the lakes is considered to have increased the run-off and hence the levels of nutrients in one lake.

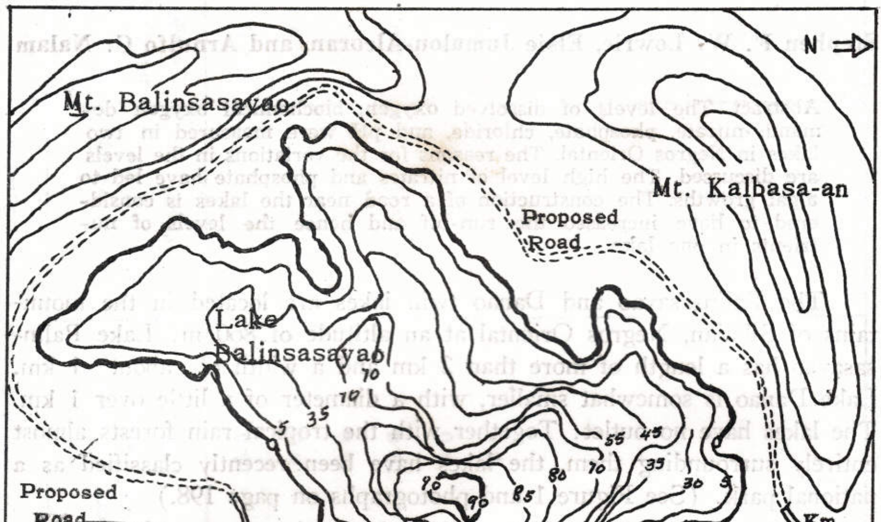
The Balinsasayao and Danao twin lakes are located in the mountains of Sibulan, Negros Oriental at an altitude of 860 m. Lake Balinsasayao has a length of more than 2 km and a width of about 1 km. Lake Danao is somewhat smaller, with a diameter of a little over 1 km. The lakes have no outlet. Together with the tropical rain forests almost entirely surrounding them, the lakes have been recently classified as a national park. (See Figure 1 and photographs on page 198.)

In the past there has been some deforestation around the lakes by *kaingeros,* slash-and-burn farmers, who also supplement their diets by fishing for *tilapya* in the lakes. Deforestation leads to soil erosion, and nutrients such as nitrates and phosphates may be washed into streams which feed the lakes. A surfeit of these nutrients could lead to the formation of algal blooms, or eutrophication, which would deplete the waters of dissolved oxygen and decrease the lakes' ability to support fish and other organisms.

A road from the town of San Jose, finished in 1977, has been cut immediately adjacent to Balinsasayao and is angled such that run-off from the forest flows directly into the basin. The construction of the road has also necessitated the cutting of trees near the lakes. At present the waters of Balinsasayao are greenish, a sign of developing algal bloom. This is in contrast to Woltereck's[1] description of the waters of the lake in 1933 as being "soft and transparent." The waters of Lake Danao are still blue, however.

## Methods

Samples were taken once a month, except June and October, from May to December 1978 and in May and August 1980. Methods of analysis used were those described in "Standard Methods for the Examination of Water and Wastewater."[2] The analysis of dissolved oxygen (DO) and biochemical oxygen demand (BOD) was by the Alsterberg (azide)




1. Depths in meters.
2. Zero reckoned from mean water level May 17, 1972.
3. Mountains, existing and proposed roads not to scale.
4. Level of Lake Danao higher by 16.04 meters than Lake Balinsasayao on May 23, 1972

**Figure 1. Map of Lake Balinsasayao-Lake Danao area.**

modification of the Winkler method. Nitrate was analyzed by the phenoldisulfonic acid method and total phosphate by the ammonium molybdate method. Chloride was analyzed by argentometric titration. Samples were extracted from the sediments with $CuSO_4/Ag_2SO_4$ solution for nitrates and sodium bicarbonate solution for phosphates. In all cases the samples were treated with suitable preservatives in the field and transported back to the laboratory, where they were analyzed shortly afterwards.

**Results and Discussion**

The levels of DO, BOD, nitrates, and phosphates varied from month to month, and within each month there was often considerable variation of levels in different areas of the lakes.

Hutchinson[3] divided lakes in the topics into two extreme types based upon the temperature stratification that can develop under relatively invariant climatic conditions. In lakes of great area and moderate depth, particularly in regions of great elevation and high evaporation and in the absence of marked thermal differences between the seasons, nocturnal cooling ensures circulation throughout the year. In deep lakes, particularly in the humid tropics where insufficient nocturnal cooling takes place, the bottom temperature is determined at very rare periods of abnormally cool weather, and stratification based on relatively small differences is persistent. In the first type of lake (polymictic) the oxygen concentration is relatively high throughout the lake; in the second type (oligomictic) the hypolimnion becomes anaerobic.

These twin lakes are oligomictic, since Woltereck found that Balinsasayao contained 0.7mg/1 of oxygen at a depth of 30 m and no dissolved oxygen at 50 m. Danao contained only 0.4mg/1 of dissolved oxygen at 20m compared with 7.5mg/1 at the surface.

The dissolved oxygen in the surface waters may depend on a number of factors: (1) The solubility of oxygen in water decreases with increasing temperature; (2) More turbulent waters would mix in more oxygen from the atmosphere and hence provide larger DO values; (3) Photosynthetic organisms in the lake could release oxygen and increase the DO; (4) Respiring, oxygen-using organisms might decrease the DO; (5) The decomposition of algae and organic matter may decrease the DO.

The theoretical solubility of oxygen in water, from Truesdale et al.[4] at 24°C and at an altitude of 860m (giving a derived pressure of 682 mm of Hg), is 10.2mg/1. This theoretical value may be compared with the actual DO values in Table 1.

| | 1978 | | | 1980 | |
|---|---|---|---|---|---|
| | Aug. | Sept. | Nov. | May | Aug. |
| Dissolved Oxygen | 6.66 | 7.66 | 8.55 | 5.84 | 5.71 |
| Biochemical Oxygen Demand | 0.21 | 0.04 | 0.90 | 0.46 | 0.62 |

Table 1. Average Oxygen levels in Lake Balinsasayao, 1978 (mg/1)

Although the DO values are somewhat lower than the theoretical solubility of oxygen, these values should not be of danger to aquatic life. The increase in DO from August to November 1978 may be due to the decline in algal bloom since summer (March-June); less decomposing matter would remove less oxygen. The November DO value may be higher than other months because of stormy weather making the lake more turbulent and so facilitating mixing of oxygen in the water. Timms[5] found that in some Australian lakes low DO values resulted from destratification when anoxic hypolimnitic waters were circulated. Such a mechanism may well be of importance in Balinsasayao and Danao.

It was found that in August 1978 the DO from the northeastern, northwestern, and southwestern sides of the lake was lower (6.9 to 7.0 mg/1) compared to more central parts (6.1 to 6.3 mg/1), probably because of the decaying algae and organic matter that collected at the sides. During September and November there was less variation in DO values between different parts of the lake.

The two readings from 1980 were slightly lower than 1978, which may indicate greater organic pollution or different weather conditions. The surface temperature of the lakes was 24°C in August 1978 and 24.5°C in August 1980, the higher 1980 temperature possibly leading to greater activity in the lake. In 1980 there was only 0.5°C temperature difference between May (24°C) and August (24.5°C) in the surface waters. During 1980 there was less variation in DO values in different parts of Balinsasayao (5.76-6.00 mg/1 in May; 5.4-5.8 mg/1 in August).

During 1978 the DO of Danao Lake was also measured and found to be 6.75 mg/1 in May and 6.43 mg/1 in August (average values). The fact that these values are higher than those for Balinsasayao indicates greater organic pollution in the big lake. In 1932-33 Woltereck measured the DO of Danao as 7.5 mg/1; unfortunately he did not report the DO of Balinsasayao. However, as he reported that Danao was more polluted, higher values for Balinsasayao would have been expected. Since most of our values are lower than Woltereck's, it may be concluded that the pollution in the lakes has increased in the past fifty years.

Biochemical Oxygen Demand (BOD) is a measure of pollution by organic compounds. Table 1 shows small values, indicating little pollution of this nature. The August value is higher than September's probably because of the greater amount of decomposing algae in August. The November value was the highest obtained for BOD and may be attributed to the stormy weather, with rain washing more decaying organic matter from the forest into the lake. In November the northern side of the lake, nearest to where the road runs, had a higher BOD (1.56 compared to 0.25 mg/1) than other parts of the lake. In August the sides of the lake with low DO values tended to show higher BOD values than the rest of the lake, suggesting that organic matter was washed into the lake on these sides. The BOD of Danao was measured in 1980 and found to be 0.12 mg/1 in May and 0.13 mg/1 in August. These values being smaller than the values for Balinsasayao during the same months again suggests that the latter is more polluted.

Nitrates and phosphates play an important role in the production of algal bloom.[6] These nutrients may either arise from the sediments of the lakes or come from run-off and solid matter washed into the lake.

| | 1978 | | | | | 1980 | |
|---|---|---|---|---|---|---|---|
| | May | July | Sept | Nov | Dec | May | Aug |
| Balinsasayao | 0.44 | 6.42 | 35.4 | 17.1 | 15.1 | 32.1 | 13.3 |
| Danao | 0.44 | 4.43 | – | 15.1 | – | 28.9 | 8.9 |

Table 2. Average Nitrate levels in waters of the lakes (mg/1)

From Table 2, it is evident that there is a great variability in the levels of nitrates in the lakes. Other workers[7] have encountered this phenomenon in other lakes and related it to the growth of algae. When algae grow on the the surface they remove nitrate from the water. This is postulated as being the cause of the reported variability, since the time of lowest nitrate content in May 1978 was the time of greatest algal bloom on the surface. The values in Danao are always lower in any given month than those in Balinsasayao, thus the former has less nitrate in its system and can support less growth of algae. As has been stated, Danao is visibly less polluted. In general the DO levels decrease with decreasing nitrate level, since the algae remove both nitrate and oxygen from the water.

Nitrate values in surface waters are commonly around 5 mg/1; the World Health Organization places an upper limit of nitrate in drinking water at 45 mg/1. The waters of the twin lakes are therefore safe to drink, although during some months they contain high levels of nitrates. These high values may be explained by the run-off from the forests around the lake. It was found that the levels were lower in the center of the lake; the sides, particularly near the road, showed higher values. Also, the sides of the lake being shallower, the surface water has greater contact with the bottom so that more nitrates may be dissolved out of the sediments. The levels of extractable nitrates in sediments were measured (in 1980) and found to be 8.3 to 15.0 mg/1 for Balinsasayao and 9.0 to 20.2 mg/1 for Danao. It was also found that sediments near shore contained higher levels. This could be accounted for by the washing of soil into the lake; sediments farther from the sides have had longer residence in the lake and consequently have been leached of more of their nitrates.

| 1980 | Average Phosphate levels in water | | Phosphate levels in sediments (extractable) | |
|---|---|---|---|---|
| | Balinsasayao | Danao | Balinsasayao | Danao |
| May | 13.0 | 17.7 | 4.2-50 | 10.0-26.0 |
| Aug. | 17.4 | 16.1 | | |

Table 3. Phosphate levels (mg/1)

The phosphate levels in the water were found to be higher than those expected in uncontaminated surface waters (usually less than 1 mg/1). Some very polluted lakes have been measured at greater than 100 mg/1,[8] hence the twin lakes are not grossly polluted, although there is certainly enough phosphate to support an algal bloom. The levels in sediments taken from an area near dwellings had higher phosphate levels, presumably due to human wastes. Phosphate release from the sediments depends on many factors, but in oligomictic lakes phosphate is released from the sediments under the reducing conditions produced by lack of dissolved oxygen in deeper waters.[9] The high phosphate levels in the waters of the twin lakes are postulated to result from release from sediments and from soil and water washed into the lakes.

The chloride levels of both lakes were found to be 3.55 mg/1, similar to the levels reported by Woltereck, 1932-33. The pH of the lakes ranged from 7.0 to 7.5, compared to 8.0 recorded by Woltereck.

## Conclusion

The levels of nitrates and phosphates in the twin lakes are high enough to support algal growth, and it is perhaps somewhat surprising that such growth is not more prevalent. The dissolved oxygen levels are sufficient to support aquatic life and the BOD levels indicate a relative lack of organic pollution. It is evident that the road on the northeast side of Balinsasayao has contributed to increased run-off, leading to higher levels of nitrates, phosphates, and BOD, with lower DO values in the vicinity of the road.

It is to be hoped that there will be no further road construction around the lakes, since this would mean more destruction of the forest and further soil erosion causing increasing nutrient levels in the lakes. The lakes are an important source of food for people living nearby. The lakes also provide drinking water and have recreational and educational uses. Any destruction of this beautiful and important ecosystem should be strongly resisted.

## Acknowledgements

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