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PHYSICAL AND CHEMICAL PROPERTIES OF WATER: CASE OF TAAL LAKE, PHILIPPINES

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ABSTRACT: Water quality can affect the ecosystem at several trophic levels. It is very important for an ecosystem to have healthy water bodies as lives of aquatic species depend upon them. Taal, with a small lake located in the southern part of Luzon in the Philippines is teeming with aquatic resources, yet it is observed that its water quality is deteriorating. The lake is surrounded by several municipalities with tributaries contributing to its quality. This study evaluated Taal lake ecosystem in six sample sites in terms of physical and chemical attributes utilizing secondary data obtained from the Department of Environment and Natural Resources (DENR). Mean values of pH, temperature and Total Soluble Solids (TSS) were within the standards set by the agency. However, there was a slight increase in Dissolved Oxygen (DO) and a low Biological Oxygen Demand (BOD). There is high nitrogen and heavy metal contamination with one highly contaminated site. This was attributed to high municipal and kitchen waste disposal and high amounts of fertilizers used in fields. Taal lake aquatic ecosystem can be classified as severely polluted based on the chemical parameters. Nitrate, phosphate, oil and grease, pH, temperature and DO levels vary significantly from site to site. Levels of arsenic, chromium, TSS and BOD do not show any significant difference among the sites.

Keywords: Chemical, Physical, Quality, Taal Lake, Water

1. INTRODUCTION

The health condition of every human is co-related to the environment or surrounding where he or she lives. With the rapid urbanization, increasing population, human and industrial activities and more so the extreme climatic condition, the world has seen some drastic changes to acknowledge that our environment is severely affected. Lakes and other freshwater ecosystems provide essential services to the society. Most important of these services is fresh drinking water, power generation, water for bathing, sites for recreational activities and important fisheries.

One of the most important body of water in the southern island of Luzon in the Philippines is Taal Lake. Taal Volcano, a famous site is seated in the middle of the Taal Lake. Taal Lake, formerly known as Bombon Lake, is also the deepest and the third largest Lake in the Philippines. Taal Lake is located in Southern Luzon, Batangas Province, (approximately 60 km. south of Manila) is surrounded by nine (9) towns and two (2) cities translating into 287 barangays. It has a total area: 24,356 hectares, with a circumference of 120 kilometers; a maximum depth of 198 meters or an average of 60 meters (PCCARD, 1981) and a shoreline of 82,500 m.

The lake is a major source of livelihood for most of the local dwellers. Fishing as one of the main jobs provides for the living of the community. Lake fisheries provide livelihood to around 20,000 fisherfolk.

The resource is used for aquaculture, recreation, tourism, navigation, and water source for Tagaytay. The Lake is known for its ecosystem that supports a diverse aquatic fauna comprising of both freshwater and marine species. Records of fish found in the lake by Albert W. Herre revealed 32 families of varied finfish resource, consisting of about 100 species, most (76 species) of which are migratory (BFAR Profile). In 2016, Taal Lake has a total fish production of 80,690MT, a majority of which comes from fish cage production.

A total number of thirty-seven (37) side streams surge into the Lake and its only outlet is the Site F [1]. The lake quality is determined by the effluents discharge in the tributaries. This is turn characterizes the aquatic conditions where fishes and other freshwater lake organisms live.

Global climate change is modifying freshwater productivity by changing the global area of these ecosystems by increasing their temperature and revising stratification. Extreme heating of surface waters between 30° N and S, associated with the high heat of vaporization of water, will result into rise in salinity of inland waters at low latitudes and loss of productivity of key organisms [2].

Water quality monitoring can help researchers predict and learn from natural processes in the environment and determine human impacts in an ecosystem. These measurement efforts can also assist in restoration projects and ensure that environmental standards are being met. Human intervention also has noticeable effects on water quality. Activities that harm the environment directly by severely polluting them like discharge of domestic, industrial, urban and other wastewaters into the water course, whether intentional or accidental, and the spreading of chemicals on agricultural land in the drainage basin are the most obvious anthropologic destruction brought to the aquatic ecosystem. Any significant changes to the natural water quality are usually disruptive to the ecosystem [3].

The quality of a lake's water depends mostly on their physical, chemical and biological well-being. The degradation of water quality can affect not only the aquatic life but the surrounding ecosystem as well. Thus, a thorough assessment of water quality is an integral part of the lake's environmental monitoring. In this research, water quality was determined by reviewing the physical and chemical properties of water. The physical parameters such as temperature, pH, total dissolved solids, dissolved oxygen and biological oxygen demand was evaluated. Chemical properties include concentration levels of arsenic, chromium, nitrates, phosphates, oil and grease.

The temperature of water has less to do with the type, and more to do with the depth of water. Smaller bodies of water, like ponds, lakes and rivers, fluctuate more easily. This affects what kind of life can live there [4]. The significance of excessive turbidity in water on fish and other aquatic life begins by altering the temperature structure of lakes. Bottom-level temperatures are usually lower in turbid lakes or ponds than in clear ones. Generally, in many lakes, lower temperatures mean lower productivity. Turbidity also prohibits with the piercing of light. This reduces photosynthesis and thereby decreases the primary productivity upon which the fish food organisms survive. As a result, fish production is reduced. Also, by prohibiting light, turbidity makes it difficult for aquatic life to find food. Adversely, some organisms may be similarly protected from predators [5].

In streamlets, increased sedimentation and siltation can take place, which can result in degradation to habitat areas for fish and other aquatic life. Particles also supply attachment places for other pollutants, notably metals and bacteria. For this reason, turbidity readings can be used as an indicator of probable pollution in a water body. The particles of turbidity provide "shelter" for microbes by minimizing their subjection to attack by antiseptics. Microbial attachment to particulate material has been contemplated to aid in microbial existence [6].

pH is a measure of how acidic/basic water is. It ranges from 0 - 14, with 7 being neutral. Total Dissolved Solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water.

Dissolved Oxygen is the amount of gaseous oxygen (O2) dissolved in the water. Oxygen enters the water by direct absorption from the atmosphere, by rapid movement, or as a waste product of plant photosynthesis. Water temperature and the volume of moving water can affect dissolved oxygen levels. Biochemical Oxygen Demand is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment. The higher the BOD value, the greater the amount of organic matter or "food" available for oxygen consuming bacteria.

Arsenic, although being toxic and probably carcinogenic when exposed through drinking water, has received very little attention in these past years. Potential pollution hazard of arsenic comes from ingesting it rather than eating arsenic-containing aquatic organisms. Although arsenic is greatly concentrated in aquatic organisms, it is evidently not progressively concentrated along a food chain. Additionally, arsenic in flesh has low toxicity, in general. Use of arsenic, the burning of fossil fuels, increased erosion of land, and the mining and processing of sulfide minerals have increased the amount of arsenic entering the lakes [7].

A range of 10 to 70 ppm arsenic has been commonly detected in household detergents and pre-soaks. Arsenic is present in detergents in arsenate state (V) and not in arsenide (III), a toxic form that is prepared for pesticide-use available commercially.

Chromium (VI) is a well-known priority polluting as well as highly toxic heavy metal. Maximum allowable concentration of chromium (VI) in drinking water is 0.05 mg/L [8]. Hexavalent chromium forms many soluble salts that can enter body membranes and induce a toxic response. Rats, mice, beagle, aquatic plants and fish species, all are affected adversely because of Cr (VI) pollution [9].

Nitrate is colorless, odorless and tasteless compound present in water. Common sources of nitrogen are fertilizers, manure, municipal wastewater, sludge, animal feedlots, septic systems, etc. Purification of nitrate-contaminated water can be done by treatments of distillation, reverse osmosis, ion-exchange, blending, charcoal filters and water softeners. Other health factors such as diarrhea and respiratory disease have also been associated with high nitrate levels in water [10].

Discharge of organic matter to water is one of the major sources of nutrients to seep through, since aerobic decomposition of such organic matter can result in release of phosphates, nitrates, etc., especially on domestic sewage containing high phosphate concentrations coming from detergents [11]. Agricultural run-offs and food-processing effluents are high in phosphate. Water analysis of water entering and leaving nine commercial trout farms three times during summer showed that concentrations of ortho-phosphate in the water may increase substantially during passage through the farm. Hence, magnetic separation can be applied to all waterborne contaminants and removing the dissolved orthophosphate from the aqueous slurry [12].

The main cause of oil and grease water pollution is anthropologic activities. Water bodies situated near colleges, parks and other public institutions had high concentration of oil and grease particles in water due to drainage of cafeteria which also cause BOD and TSS value to be higher than normal in the lake. This has now been declared as one of the main factors that cause mass fish death in lake ecosystems [13].

It is important here to note that oil which forms a surface film on the river can coat plants and animals cutting or reducing their supply of oxygen from the above lying atmosphere. Transmission of light is affected due to the formation of oil film that floats above the body of water. This disturbs the photosynthesis process of aquatic plants. In animals, insulating properties of furs and feathers are affected. Mobility is also reduced due to increased stickiness once the oil starts to dry [14]. Eventually, in most cases, this leads to death. Oil bio accumulates in the higher animals and further enters the food chain. Detergents create frothing and can harm invertebrates and fish, as they are a major source of phosphates. Moreover, petroleum or grease spilled over water also produces chemicals that are extremely harmful for marine animals [14].

With the foregoing significance of Taal Lake to the community, it is but noting that quality of its water be monitored. The Department of Environment and Natural Resources (DENR) and the Bureau of Fisheries and Aquatic Resources (BFAR) are the two main government agencies that look after the quality of the Philippine waters. Water monitoring is regularly done to ensure preservation of the water quality and safety of the consumers. The study summarizes the physical and chemical properties of Taal Lake from six different sites where a comparison is also done.

Natural resources are the important wealth of our country, and water is one of them. Water is a wonder of nature. “No life without water’’ is a common saying given the fact that water is the one of the naturally occurring essential requirement of all life supporting activities [15]. Impurities present in water reduce its quality and its use. This would affect the health of both cultured and wild species as water quality is a major factor controlling them. The quality of water can easily be described by the physical, chemical and biological parameters or characteristics [16]. Physio-chemical variables are important environmental factors of water in which all biological communities live in association with each other [17].

2. RESEARCH SIGNIFICANCE

Water quality is a very important component of human living. Water monitoring is regularly done to ensure preservation of the water quality and safety of the consumers. Water quality monitoring can help researchers predict and learn from natural processes in the environment and determine human impacts in an ecosystem. For the community, awareness on the environmental conditions enables us to realize the degradative effects it contributes to the rich natural resources of the locality. The lake is a major source of livelihood for most of the local dwellers. Through this research, the local people will be able to understand and value this natural resource. For the local government, these measurement efforts can assist in restoration projects and ensure that environmental standards are being met. Policy makers are provided with empirical data to support plans of action. For the education sector, the information provided herein can be used as reference materials for discussions on environmental sustainability topics.

3. OBJECTIVES OF THE STUDY

This study aimed to present the water quality of Taal Lake in the Philippines by analyzing the physical and chemical properties of water from different sites and compare them with the acceptable standards. The physical properties of the water include pH, temperature, total soluble solids, dissolved oxygen and biological oxygen demand. The chemical properties include Arsenic, Chromium, Nitrates, Phosphates, and Oil and Grease were also presented. A comparative analysis of the physical and chemical parameters among sites was done.

4. METHODS

This study utilized a descriptive research design aimed to present the concentration level of different chemicals in the locality of Taal Lake’s aquatic ecosystem. The study used a mixed method which consists of both quantitative and qualitative data. Secondary data collected from 2013 to 2018 by the Department of Environment and Natural Resources (DENR) in Site A, Batangas was used in the analysis.

Corresponding number of water samples (Table 1) were taken from six different sample sites within the vicinity of Taal Lake (Fig. 1). Taal Lake is the third largest lake present in the southwestern region of Luzon in the Philippines.

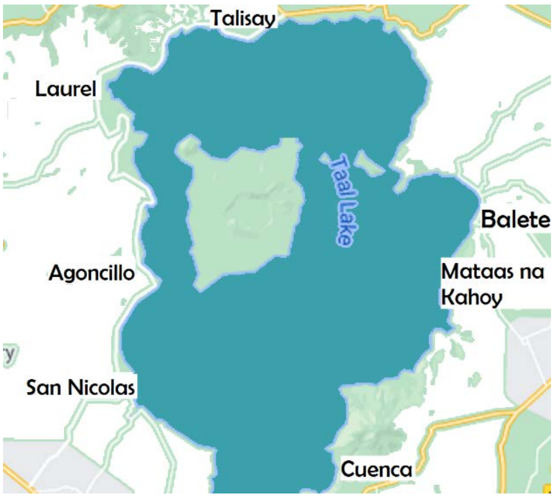

Fig. 1 Taal Lake Vicinity

It occupies a volcanic crater with a maximum width of 24 kilometers and is 3 meters above sea level. At least four samples per site was collected for physical and chemical analysis. Water samples were collected and placed in 1L sample in PET bottle and 1L sample in wide mouth glass bottle. Samples were immediately taken to the laboratory located in local BFAR office for analysis. Some data such as temperature and pH were collected on site.

Table 1. Sample size per location

Location	Sample size
Site A	7
Site B	5
Site C	13
Site D	4
Site E	5
Site F	4

Water analysis was performed following the procedures in the Standard Methods for the Examination of Water and Wastewater, 22nd ed, APHA, AWWA, WEF, Washington DC 2012. Standard values used for comparison is contained in DAO No. 2016-08 Water Quality Guidelines and General Effluent Standards of 2016. Physical parameters measured were pH, temperature, total soluble solids, dissolved oxygen and biological oxygen demand. Chemical parameters measured were arsenic, chromium, phosphate, nitrate and oil and grease.

All chemical tests collected were compared to the standard parameter table from the Bureau of Fisheries and Aquatic Resources (BFAR) (Table 2). Weighted mean has also been used to identify the average value of different study sites.

Table 2. Standard Values Set by DENR-EMB

Physical and Chemical Parameters	Standard Values (for class B)
pH	6.5 – 8.5
Temperature	24-27 degree C
Total Soluble Solids	Not more than 30% increase
Dissolved Oxygen	5(minimum)
Biological Oxygen Demand	5(minimum) - 10(maximum)
Arsenic	.01 mg/L
Chromium	.001 mg/L
Nitrogen as NO_3	7 mg/L
Phosphorous as PO_4	0.5 mg/L
Oil & Grease	1 mg/L

5. RESULTS AND DISCUSSION

5.1 Physical Properties of the Lake Water

Physical water quality parameters such as pH, temperature, total soluble solids and dissolved oxygen fall under control set by DENR-EMB whereas levels of biological oxygen demand fall short to the standards set. Table 3 shows the results of the analysis of the physical parameters, pH and temperature.

The pH concentration levels were found highest in Site F is more than 8 whereas lowest in Site B counting some less than 7. All sites show acceptable pH levels. Changes in the pH value of water are important to many organisms. Most organisms have adapted to life in water of a specific pH and may die if it changes even slightly. This is especially true of aquatic macroinvertebrates and fish eggs and fry. The pH is a critical factor determining the health of a waterway. The factors that control it are obviously complicated. As with many environmental concerns, we need to be aware of the implications of any impacts we have upon the environment. [18].

Changes in pH is caused by natural conditions (especially in swamps), dumping of waste (batteries) and farm runoff (lime). Most aquatic life cannot withstand water outside the optimum pH thus resulting in death.

Highest mean temperature recorded was around 27.6 from Site F while lowest was less than 26 from Site B. Site F being the only outlet of the lake and is a large stream, has a larger surface area which also encourages higher temperature compared to other sites [19]. Elements such as sunlight, heat transfer from the atmosphere, stream confluence and turbidity affect water temperature. Shallow and surface waters are more easily influenced by these factors than deep water [20].

Table 3. pH and Temperature by Location

Location	pH	Temperature ºC
Site A	7.25	27.35
Site B	6.97	25.92
Site C	7.25	26.47
Site D	7.36	25.96
Site E	7.51	26.96
Site F	8.23	27.58

Table 4 shows Site E, Site C and Site F had most levels of mean Dissolved Oxygen (DO) which is more than 6 whereas Site B was lowest falling few short of level 4. Just as we need air to breathe, aquatic organisms need dissolved oxygen to respire. It is necessary for the survival of fish, invertebrates, bacteria, and underwater plants [21].

DO is also needed for the decomposition of organic matter. Water with high concentrations of dissolved minerals such as salt will have a lower DO concentration than fresh water at the same temperature. Low dissolved oxygen (DO) primarily results from excessive algae growth caused by phosphorus. As the algae die and decompose, the process consumes dissolved oxygen [22]. All our sites except site B have good levels of dissolved oxygen which is healthy and no sign of threat. Oxygen enters the water by direct absorption from the atmosphere, by rapid movement, or as a waste product of plant photosynthesis. Water temperature and the volume of moving water can affect dissolved oxygen levels [23]. Dissolved Oxygen is found abundant from each sample that showcases the standard of ecosystem persisting in the premises is in healthy condition.

Table 4. TSS, DO and BOD by Site

Location	Total Soluble Solids	Dissolved Oxygen	Biological Oxygen Demand
Site A	22.48	4.41	8.00
Site B	11.28	3.95	2.95
Site C	31.48	6.51	3.26
Site D	29.56	5.70	3.33
Site E	32.35	6.66	2.18
Site F	10.31	6.43	3.19

Ideally, the average level of DO desirable for aquatic habitat is 9.0 ppm (parts per million). This provides good habitat for abundant fish population. Below 9ppm but higher than 7 ppm supports growth and aquatic activities while 5 ppm can still support spawning. When the level of DO is below 5, the condition becomes stressful for aquatic animals and there is about 12 to 24 hours of tolerance for growth. Below 3 ppm could hardly support fish population.

Site A region of Taal Lake has almost double levels of BOD compared to others and highest at 8.00 ppm whereas lowest stands in Site E levelling a few more than 2. Oxygen consumption is affected by a number of variables: temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water [24]. When the water body has high BOD, aerobic bacteria will utilize the available DO of water. In case of excessive BOD there will be deficiency of DO and water will be in anaerobic condition resulting in mortality of living aquatic organisms and release of ammonia, methane, CO_2 etc. In absence of oxygen, anaerobic bacteria become active. When BOD value is medium, water will possess excessive nutrients causing algal bloom. Such condition is again dangerous because during daytime water will be supersaturated with oxygen (due to photosynthesis in presence of sun light), but at late night DO may be zero or close to zero. This is primarily due to utilization of oxygen for respiration by plants and animals (without any production of oxygen in absence of sunlight). For this purpose, BOD must be maintained up to certain level in any surface waterbody [25]. All other sites except site A falls below the minimum requirement for BOD.

Somehow the physical factors of the Lake Taal have a corresponding influence on each other. Higher amounts of total dissolved solids will lower the temperature because these solids won't allow sunlight to reach enough depth of the water body. The physical properties do not correlate even if they are from same structure since its properties depend upon different factors like the surrounding it is situated or human interaction around. Temperature and pH levels also should be suitable for the life survival existing in the water body with abundant supply of Oxygen. According to Galera & Martinez [26], the water surface temperature, pH, total dissolved solids, total suspended solids, color and dissolved oxygen of Taal lake in 2009 conformed the class C water standards (DENR AO 34, 1990) and was therefore safe for aquaculture use.

5.2 Chemical Parameters of the Lake Water

Tables 5, 6 and 7 show the result of the chemical analysis of the water in the different sites. In Site A, the levels of arsenic, chromium and nitrogen are found to be over the standard limit set by BFAR with nitrogen levels being almost 6 times higher than the standard limit. The levels of phosphorous, and oil and grease are within the standard limit but dangerously close to the threshold value. A sampling point has given output of 180 mg/L nitrogen while 7mg/L is the standard set. A sample point shows nitrogen levels of 66mg/L.

Table 5. Levels of Arsenic and Chromium by Site

	Chemical parameters	
Location	Arsenic	Chromium
Site A	0.025	0.029
Site B	0.03	0.03
Site C	0.028	0.034
Site D	0.021	0.023
Site E	0.024	0.052
Site F	0.025	0.024

Higher nitrogen levels mean possible overstimulation of algae and aquatic plants which could lead to lack of oxygen for fishes. In Site B, every chemical parameter was more or less near the standard limits set by BFAR. Only one sample from the five sampling points had minimal nitrogen pollution (Table 6). This means that there will soon be an algal bloom and possible eutrophication, if not taken care of. Nitrogen in water comes mainly from fertilizers and insecticides.

Site C shows very unsatisfactory data results with only phosphorous levels being within tolerable standards while all other chemical parameters exceeded the standard limit. Nitrogen pollution was in excess with samples from two sampling points showing levels higher than 30 mg/L. Heavy metal pollution of arsenic and chromium show heavy unregulated industrial discharge which may be a determining source in Site C. Nitrogen in water comes from kitchen wastes and fertilizers and causes eutrophication in water causing death of the lake, if not controlled soon enough.

Site D samples show heavy metal pollution with higher levels of arsenic and chromium (Table 5). Other chemical parameters (nitrates, phosphates, oil and grease) are found to be within standard limits. The levels of arsenic and chromium are not dangerously high as seen in previous sample sites, but still, any situation can amplify if not taken seriously. This means industrial effluents loom in large amount polluting waters near Site D. Constant erosion of volcanic rocks with arsenic and chromium content is another possible source. Site E is another problematic place as arsenic, chromium, nitrate, and oil and grease levels are all found to be above the standard limit with only phosphorous being within tolerable limit. Most nitrogen and chromium outputs are found from two of the five sampling points. Nitrogen can cause eutrophication and lack of oxygen. Their possible source can be pesticides and insecticides. Chromium excess happens when volcanic rocks erode and heavy industrial effluents are dumped into the lake water.

Site F had all other chemical parameters in optimum levels except nitrogen. In fact, nitrogen pollution looms at large as values reach as high as 592mg/L (standard is 7mg/L) which indicates high level of eutrophication. Heavy use of fertilizers and pesticides in the area around Site F and domestic sewage could be the reason for excess nitrogen. Highest amount is found in one of the four sampling points (592mg/L), followed by 487mg/L and 420mg/L found at the two other sampling points.

The standard limit for arsenic set by BFAR is 0.01 mg/L. All the sample sites have higher values (highest to lowest: Site C, Site B, Site A, Site F, Site E, Site D) than the standard limit indicating arsenic pollution in Taal Lake. After Metro Manila, Batangas is known for being an industrial growth sector in its region. Site C is known for its booming agriculture and real estate industries. Hence, industries can be a major contributing arsenic pollutant. Arsenics are used in industrial processes to produce antifungal wood preservatives, cosmetics, for making residential structures, playhouses, decks, fences, picnic houses, insecticides and pesticides [27]. The values, however, do not show significant differences when compared among the sample sites.

Phosphate levels in Taal ecosystem is in better control with only Site F having levels above standard limit. Standard value for phosphate is 0.5mg/L. All other sites have levels lower than that of Site E showing level of just 0.07mg/L. Taal Lake has many illegally built fish cages and this cause eutrophication problem as fishermen would throw nutrients in water without any regulation. But in the recent times, all illegal cages have been removed but Site F still shows low amounts of phosphate contamination, possibly still due to excessive nutrient being laid in water for fishes [28].

Table 6. Levels of Nitrogen and Phosphorous by Site

	Chemical parameters	
Location	Nitrogen as NO3 (mg/L)	Phosphorous as PO4 (mg/L
Site A	41.813	0.435
Site B	3.940	0.245
Site C	18.571	0.084
Site D	7.149	0.416
Site E	9.277	0.072
Site F	375.05	0.587

Table 7 shows values for oil and grease vary among sites with highest value in Site E (1.6mg/L).

The standard value set by BFAR is 1mg/L. Site C had value of 1.5mg/L. The rest of the sample sites are more or less within tolerable value range, with Site F showing levels of 1.08mg/L, followed by Site A with 0.9mg/L and Site D with 0.7mg/L. Again, Site C and Site E have slightly higher levels of oil and grease than the standard parameter set by BFAR. Sources of oil and grease are mostly anthropogenic with most oil and grease accumulating in lakes from residential sewage drains and dumping of industrial byproducts. The more people using automobiles and moving machineries, the more oil and grease are being used, thus, contribute more to the pollution [29].

Table 7. Level of Oil and Grease by Site

Location	Oil & Grease (mg/L)
Site A	0.939
Site B	1.460
Site C	1.519
Site D	0.781
Site E	1.620
Site F	1.081

All physical attributes of water quality of Taal lake were found fit into the criteria set by DENR-EMB except the balance of Oxygen levels which were more than required; hence, lowering biological oxygen demand of water. No significant differences were found in mean measures of total soluble solids and biological oxygen demand whereas mean evaluation of parameters such as pH, temperature and dissolved oxygen show notable differences. Based on the overall results of the study, Taal Lake water can still be classified as Class B (DENREMB, 2005), Recreational Water Class I. The classification is the same with two other river basins in the Philippines (DENR-EMB, 2005). Taal lake aquatic ecosystem can be classified as severely polluted based on the chemical parameters analyzed in this study. Nitrate, phosphate, and oil and grease levels vary significantly from site to site. Values of all other parameters such as arsenic and chromium do not show any significant difference. All the sample sites have heavy metal contamination. Taal Lake shows very high levels of arsenic and chromium with Site C having highest arsenic levels and Site E having highest chromium levels. When it comes to nitrate levels that determine algal content in a lake, all sample sites, except Site B, have higher values than the set standard levels. Site F shows extremely high levels of nitrogen. Phosphate levels are under control. Site C and Site E also shows high oil and grease levels. This data indicates high industrialization in Site C and Site E. A common contaminant found through this study is nitrogen. This indicates high municipal waste disposal, kitchen waste disposal, and high fertilizers used in fields around Taal Lake.

A major problem that Taal Lake's ecosystem is combating is heavy metal pollution. Arsenic and chromium levels are above standard levels in all sample sites. There are costly methods like ion exchange and membrane technology but local communities in developing countries cannot afford it. Many other alternative methods are available. One of the suggestions is switching from an arsenic-unsafe well to an arsenic-safe drinking water source or use deep tube wells (which are generally arsenic free). Technologies for arsenic removal include oxidation, coagulation-precipitation, absorption, ion exchange, and membrane techniques. There are increasing number of effective and low-cost options for removing arsenic from small or household supplies.

Nitrate pollution looms at large in Taal Lake as levels are extremely high and eutrophication is inevitable. Eutrophication can possibly lead to death of the precious, endangered, endemic species residing in Taal Lake due to lack of sunlight and oxygen. Excess of nitrate also leads to excess oxidation and excess phosphates. Nitration can be treated by adsorption techniques by using best adsorbent according to the location [30]. For preventive measures, nitrogen leaching into water from soil can be prevented by avoiding over-irrigation as it increases the chances of nitrate leaching. Upgrading manure storage sites can reduce manure leaking. Efforts should be made to reduce the amount of nitrogen applied to older sites and collect drainage water instead of allowing it to drain in Taal Lake.

In order to maintain and conserve the condition of water in Taal Lake, safety, security, and environmental management plan should be carried out by concerned local government units (LGUs). This way the best favorable use of the Lake is likely to be encouraged. Likewise, information campaign on the protection and preservation of the Lake has to get in touch with the nearby natives and mountaineers to reduce the quantity of contaminants in the surrounding locale.

6. CONCLUSION

The physical properties of the water such as pH, temperature and Total Soluble Solids (TSS) were within the standards set by the agency. There was a slight increase in Dissolved Oxygen (DO) and a low Biological Oxygen Demand (BOD). There is high nitrogen and heavy metal contamination with one highly contaminated site. This was attributed to high municipal and kitchen waste disposal and high amounts of fertilizers used in fields. Taal lake aquatic ecosystem can be classified as severely polluted based on the chemical parameters. Nitrate, phosphate, oil and grease, pH, temperature and DO levels vary significantly from site to site. Levels of arsenic, chromium, TSS and BOD do not show any significant difference among the sites.

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