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Research Article

# ANALYSIS OF EFFLUENTS DISCHARGED TO ASHTAMUDI LAKE FROM CHINA CLAY INDUSTRIES

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**ABSTRACT**

Ashtamudi Wetland is famous for its hydrological functions, its biodiversity, and its support for fish with nearly 100 species sustaining a lively fishing industry. This paper reveals the physico-chemical properties of water samples discharged to the Ashtamudi Lake from china clay industries in Kollam district of Kerala state in India. Water samples collected from the lake were also analyzed. The results indicated that most general physico-chemical properties of the lake water fell within those recommended for domestic water. However the dissolved oxygen present in water is a highly fluctuating parameter which will affect its biodiversity.

**Keywords:** Water quality parameters, Effluent analysis, Ashtamudi Lake

## INTRODUCTION

The location of Ashtamudi Lake is in Kollam district of Kerala state. This lake has about 32 square km water spread area. The areas surrounding the lake are well known for China clay deposits. There are clay mines as well as clay refining industries in this area. A part of the effluents from refining industries are discharged to Ashtamudi Lake. Our efforts are to study the impact of effluents in the eco system of the lake which is famous for special varieties of fish. For the study, we have selected Kanjiracode area of the lake.

## MATERIALS AND METHODS

The selected area of the lake is very near to clay mines and a refining plant. Locations from where samples were collected for the study are as shown below.

Sample I - Fresh water samples which are used by the industry.

Sample II - Effluent coming out of processing plants.

Sample III - Recycled water of processing plant, a part of which is discharged to lake.

Sample IV - Water from common effluent outlet

Sample V - Water from Ashtamudi Lake

Samples were collected from these five locations four times giving a gap of about 30 days between two samplings. Water samples from the selected sites were collected during December2009-March 2010 and taken in pre-cleaned polyethylene bottles. The samples after collection were immediately placed in dark boxes.

The collected samples were analyzed for major physical and chemical water quality parameters like pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), $Ca^{2+}$, $Fe^{3+}$ etc as per the method of Assessment of Ground Water Quality described in Standard methods for the examination of water and wastewater, American Public Health Association (APHA) [1, 2] and other reported methods [3, 4].

The chemical and physical parameters exhibited considerable variations from sample to sample. All the measurements were carried out under identical conditions and the analytical data of the present investigations are summarized in Tables 1 - 5.

## RESULTS AND DISCUSSION

pH is considered as an important ecological factor and provides important information in many types of geochemical equilibrium or solubility calculation.. Generally pH of water is influenced by geology of catchments area and buffering capacity of water. Most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes. The limit of pH value for drinking water is specified[5] as 6.5 -8.5. According to the present study sample I-(Table 1) the pH vary from 6.2 to 6.83, Sample II-(Table 2) (Effluents coming out of processing plant) vary from 2.62-2.82 which is highly acidic due to the presence of the chemicals used in the clay factory.

**Table 1: Sample-I (Fresh water sample used by the industry)**

| Parameters | Set-I collected on 10-12-2009 | Set-II collected on 12-01-2010 | Set-III collected on 09-02-2010 | Set-IV collected on 03-03-2010 |
|---|---|---|---|---|
| pH | 6.83 | 6.3 | 6.32 | 6.2 |
| Conductance | 0.05 | 0.15 | 0.1 | 0.05 |
| Total solids(ppm) | 300 | 280 | 300 | 260 |
| Total suspended solids(ppm) | 5.0 | 4.0 | 6.0 | 5.0 |
| Total dissolved solids(ppm) | 295 | 276 | 294 | 255 |
| Dissolved oxygen(mg/l) | 6.027 | 6.007 | 5.560 | 6.8732 |
| Chemical oxygen demand(mg/l) | 51.2 | 38.88 | 50 | 51.2 |
| Acidity(mg/l) | 30 | 40 | 36 | 42 |
| Alkalinity(mg/l) | 27.5 | 15 | 35 | 21 |
| Chloride(mg/l) | 2 | 1 | 2.2 | 1.7 |
| Free $CO_2$(mg/l) | 8.8 | 10.12 | 11 | 8.8 |
| Dissolved$CO_2$(ppm) | 0.877 | 0.438 | 2.190 | 1.750 |
| Total hardness(mg/l) | 15 | 35 | 36 | 32 |
| Calcium(mg/l) | 901.079 | 804.9640 | 832.12 | 640.7673 |
| Nickel(mg/l) | 0 | 0 | 0 | 0 |
| Iron(mg/l) | 13.96 | 12.52 | 13.52 | 13.67 |
| Sulphate(mg/l) | 0 | 0 | 0 | 0 |

**Table 2: Sample-II (Effluents coming out of processing plant)**

| Parameters | Set-I collected on 10-12-2009 | Set-II collected on 12-01-2010 | Set-III collected on 09-02-2010 | Set-IV collected on 03-03-2010 |
|---|---|---|---|---|
| pH | 2.78 | 2.8 | 2.62 | 2.82 |
| Conductance(ohm$^{-1}$ cm$^{-1}$) | 1.4 | 1.3 | 1.4 | 1.2 |
| Total solids(ppm | 315 | 323 | 330 | 307 |
| Total dissolved solids(ppm) | 90 | 100 | 84 | 92 |
| Total suspended solids(ppm) | 220 | 223 | 250 | 215 |
| Dissolved oxygen(mg/l) | 1.0824 | 1.62 | 1.32 | 1.53 |
| Chemical oxygen demand | 360 | 335 | 460 | 412 |
| Acidity(mg/l) | 820 | 832 | 798 | 820 |
| Alkalinity(mg/l) | 0 | 0 | 0 | 0 |
| Chloride(mg/l) | 34 | 67 | 65 | 66 |
| Free $CO_2$(mg/l) | 220 | 214.5 | 262 | 198.3 |
| Dissolved $CO_2$(ppm) | 51.75 | 53.25 | 51.82 | 54.96 |
| Total hardness (mg/l) | 202 | 230 | 225 | 215 |
| Calcium (Ca) (mg/l) | 1201 | 1225 | 1315 | 1500 |
| Nickel (Ni) (mg/l) | 2043.606 | 2247.048 | 2222.64 | 2314.5 |
| Iron (Fe) (mg/l) | 293.04 | 288.52 | 296.56 | 282.10 |
| Sulphate ($SO_4^{2-}$)(mg/l) | 1234 | 1245 | 1114 | 1135 |

**Table 3: Sample-III (Recycled water of processing plant)**

| Parameters | Set-I collected on 10-12-2009 | Set-II collected on 12-01-2010 | Set-III collected on 09-02-2010 | Set-IV collected on 03-03-2010 |
|---|---|---|---|---|
| pH | 6.2 | 6.7 | 4.7 | 5.7 |
| Conductance | 0 | 0 | 0.01 | 0 |
| Total solids(ppm) | 260 | 223 | 250 | 215 |
| Total suspended solids(ppm) | 62 | 61 | 59 | 63 |
| Total dissolved solids(ppm) | 198 | 162 | 191 | 152 |
| Dissolved oxygen(mg/l) | 1.8696 | 1.6236 | 1.53 | 1.482 |
| Chemical oxygen demand(mg/l) | 128 | 210 | 198 | 188 |
| Acidity(mg/l) | 152 | 171.5 | 182.5 | 168.91 |
| Alkalinity(mg/l) | 10 | 15 | 14 | 12 |
| Chloride(mg/l) | 10 | 13 | 9 | 12 |
| Free $CO_2$(mg/l) | 307 | 288.5 | 279.4 | 303.62 |
| Dissolved$CO_2$(ppm) | 51.2 | 50.62 | 58.92 | 69.53 |
| Total hardness(mg/l) | 32 | 30 | 28 | 35 |
| Calcium(mg/l) | 3506.12 | 3012.62 | 3492.12 | 3523.6 |
| Nickel(mg/l) | 0 | 0 | 0 | 0 |
| Iron(mg/l) | 182.52 | 173.56 | 186.12 | 191.56 |
| Sulphate ($SO_4^{2-}$) (mg/l) | 4780.2 | 4506.2 | 4056.2 | 4043 |

**Table 4: Sample-IV (Water from common effluent outlet)**

| Parameters | Set-I collected on 10-12-2009 | Set-II collected on 12-01-2010 | Set-III collected on 09-02-2010 | Set-IV collected on 03-03-2010 |
|---|---|---|---|---|
| pH | 1.5 | 1.86 | 2.8 | 1.62 |
| Conductance | 3.2 | 4 | 3.3 | 3.4 |
| Total solids(ppm) | 3000 | 3502 | 3702 | 3482 |
| Total suspended solids(ppm) | 500 | 700 | 1000 | 1100 |
| Total dissolved solids(ppm) | 2500 | 2802 | 2724 | 2382 |
| Dissolved oxygen(mg/l) | 47.478 | 49.446 | 45.264 | 46.986 |
| Chemical oxygen demand(mg/l) | 24 | 96 | 184 | 155.2 |
| Acidity(mg/l) | 2080 | 2035 | 2041 | 2061 |
| Alkalinity(mg/l) | 0 | 0 | 0 | 0 |
| Chloride(mg/l) | 23 | 21.5 | 24 | 22 |
| Free $CO_2$(mg/l) | 919.6 | 919.6 | 902 | 919.6 |
| Dissolved$CO_2$(ppm) | 57.01 | 60.5 | 54.38 | 55.26 |
| Total hardness(mg/l) | 160 | 156 | 168 | 160 |
| Calcium(mg/l) | 863.03 | 640.7673 | 820.9832 | 1021.22 |
| Nickel(mg/l) | 254.19 | 262.35 | 214.52 | 272.36 |
| Iron(mg/l) | 69.8 | 63.21 | 56.82 | 70.21 |
| Sulphate ($SO_4^{2-}$) (mg/l) | 942 | 960.5 | 639.6 | 843.3 |

**Table 5: Sample-V (Water from the ashtamudi lake at kanjiracode area)**

| Parameters | Set-I collected on 10-12-2009 | Set-II collected on 12-01-2010 | Set-III collected on 09-02-2010 | Set-IV collected on 03-03-2010 |
|---|---|---|---|---|
| pH | 6.91 | 6.91 | 6.83 | 6.9 |
| Conductance | 1 | 1 | 1 | 1 |
| Total solids(ppm) | 3630 | 2990 | 1668 | 2243 |
| Total suspended solids(ppm) | 2.12 | 1.105 | 1.46 | 3.28 |
| Total dissolved solids(ppm) | 3627.88 | 2988.89 | 1666.54 | 2239.72 |
| Dissolved oxygen(mg/l) | 5.12 | 5.86 | 4.69 | 5.7 |
| Chemical oxygen demand(mg/l) | 51.2 | 88 | 256 | 92.5 |
| Acidity(mg/l) | 20 | 21 | 28 | 20 |
| Alkalinity(mg/l) | 82.5 | 84 | 120 | 106 |
| Chloride(mg/l) | 35 | 32.5 | 46 | 42.8 |
| Free $CO_2$(mg/l) | 11 | 11 | 8.8 | 11 |
| Dissolved$CO_2$(ppm) | 1.31 | 1.31 | 1.140 | 1.842 |
| Total hardness(mg/l) | 144 | 135 | 135.2 | 140 |
| Calcium(mg/l) | 300 | 562.67 | 256.34 | 452.54 |
| Nickel(mg/l) | 0 | 0 | 0 | 0 |
| Iron(mg/l) | 41.8 | 39.23 | 45.68 | 47.89 |
| Sulphate ($SO_4^{2-}$) (mg/l) | 505 | 886.52 | 464.86 | 678.77 |

A part of this water is discharged into the Ashtamudi Lake which may pollute the lake. Sample III -(Table 3), Recycled water of processing plant, has pH range 4.7-6.2. The wide fluctuations of the pH of samples collected at different times from the same location may be due to the differences in properties of raw material (clay) processed at that time. For sample IV- (Table 4), Water from common effluent outlet) the pH value varies from 1.5 - 2.8 which is also highly acidic. This water is directly flowing into the Lake. Sample V-(Table 5), Water from the Ashtamudi Lake at Kanjiracode area) pH range is 6.83 - 6.91 which is in the permissible limit of the standards approved by the Bureau of Indian Standards [5]. The low pH is toxic to fish, as pH decreases the concentration of metal may increase because higher acidity increases their ability to be dissolved from sediments into the water. pH value of the Vellayani fresh water lake ranged from 6.52 - 7.2 [6]. Our studies shows that the Ashtamudi Lake water is not polluted with respect to hydrogen ion concentration.

Conductivity is the capacity to conduct electricity and it depends on the number of ions and ionic mobility. The pH of the sample is also related to conductivity and alkalinity. It was observed that conductance is low for sample I -(Table 1) 0.05 - 0.15 and sample III-(Table 3) 0 - 0.01. For sample II-(Table 2) 1.2 - 1.4 and Sample V-(Table 5) 1.0 have moderate value but for sample IV-(Table 4) has high value 3.2 - 4.0. The increased conductivity value may be attributed to the increased concentration of the salts, ionized substances and the sediments in the water. The variability in conductivity may be due to the concentration of ionized substances present in water [7].

Total dissolved solids obtained as the difference between total solids and total suspended solids. TDS varied between 255 – 295 ppm for sample I-(Table 1), 215 – 246 ppm for sample II -(Table 2), 152 –198 ppm for sample III - (Table 3), 2382 – 2802 ppm for sample IV - (Table 4), and 1666.54 – 3627.88 ppm for sample V-(Table 5). The desired limit is 500 ppm according to the Indian Standards [5]. A high value of TDS reduces water utility in domestic, irrigation and agriculture purposes [8]. Increase in TDS due to sea water intrusion and increase in salts are reported by Mittal et al [9].

Dissolved oxygen is an important parameter which affects the chemical and biological aspects of the ecosystem. Non polluted water is normally saturated with dissolved oxygen. At 20$^{o}$ C (room temperature) and standard atmospheric pressure (sea level), the maximum amount of oxygen that can be dissolved in fresh water is 9 ppm. If the water temperature is below 20$^{o}$ C, there may be more oxygen dissolved in the sample. Generally a dissolved oxygen level of 9-10 ppm is considered very well. At levels of 4 ppm or less, some fish and macro invertebrate populations (e.g. bass, trout, salmon, mayfly nymphs, stonefly nymphs, and caddis fly larvae) will begin to decline. Other organisms are more capable of surviving in water with low dissolved oxygen levels (i.e. sludge worms, leeches).The presence of inorganic reducing agents such as $H_2S$, Ammonia, Nitrates, and other oxidisable substances tend to decrease the DO value. The DO value of sample II - (Table 2) and sample III -(Table 3) are very low, and other samples have moderate values. The lake water show DO value range from 4.69 – 5.86 this may be due to the low solubility of oxygen in saline water.

Chemical Oxygen Demand (COD) is defined as the quantity of a specified oxidant that reacts with a sample under controlled conditions. The quantity of oxidant consumed is expressed in terms of its oxygen equivalence. COD is expressed in mg/l. In potable drinking water plants, COD values should be less than 10 mg/l at the end of the treatment cycle.

Alkalinity is a measure of buffering capacity of the water and is important for aquatic life in water system because it equilibrates the pH range that occurs naturally as a result of photosynthetic activity of aquatic plants. The desirable standard limit of alkalinity of water is 120 mg/l and the maximum permissible limit is 600mg/l. Alkalinity in terms of $HCO_3^-$ of all the samples ranged from 0 - 120mg/l. The constituents of alkalinity include mainly carbonates, bicarbonates, hydroxides, phosphates, borates etc, resulting from the dissolution of mineral substances in the soil [10, 11, 12]. Alkalinity is a big problem for industries also, as alkaline water if used in boilers may lead to deposition of scales and cause caustic embrittlement which may cause explosion.

Although $CO_2$ is a minor component of air it is abundant in water as its solubility in water is 30 times more than that of oxygen. The analysis of samples for free $CO_2$ and dissolved $CO_2$ are given in Tables 1-5. There are no limits for $CO_2$ for drinking water. Its presence also affects the buffering capacity of water. $CO_2$ acts to convert calcium and magnesium salts in water into bicarbonates and causes hardness in water [13].

Total hardness is the measure of capacity of water to react with soap, hard water requiring considerably more soap to produce lather. According to ISI total hardness of domestic water is 300mg/l of $CaCO_3$. Total hardness show fluctuating trends in its values and is related with calcium, magnesium, chloride, sulphate, etc. The acceptable limits of calcium and magnesium for domestic use are 75 ppm and 30 ppm respectively.

The acceptable limit of iron is 0.3 mg/L and the desirable limit is 1 mg/L. Beyond these limits, taste and appearance are affected. It has adverse effects on domestic uses like staining of plumbing and fixtures, oily appearance on top of water body, deposits on boiling, coloration to the food prepared, promoting iron bacteria etc. Iron values are seen above acceptable limit in all the samples. On the basis of above discussion it is concluded that the effluents discharged from kaolin industry is much contaminated and exceeds the values prescribed by the Standards of Environmental Protection Act, Ministry of Environment and Forest, New Delhi and therefore, it should be treated properly prior to disposal in the environment. The presence of increased amounts of heavy metals may have a direct impact on the health of humans as well as aquatic animals [14].

Small amount of nickel is probably essential for humans, although lack of nickel has not been found to affect the health of humans. The most common adverse health effect of nickel in humans is an allergic reaction. Nickel and its compounds have high acute and chronic toxicity to aquatic life [7]. Insufficient data are available to evaluate or predict the effects of nickel and its compounds to plants, birds, or land animals. Nickel and certain nickel compounds may reasonably be anticipated to be carcinogens. Cancers of the lung, nasal sinus, and throat have resulted when workers breathed dust containing high levels of nickel compounds while working in nickel refineries or nickel processing plants. There may be no safe level of exposure to carcinogens. Carcinogens may also have the potential for causing reproductive damage in humans. Nickel may damage the developing fetus. The present study shows that lake water sample is free from nickel while effluent is contaminated with nickel and a part of which discharged to the lake directly.

The presence of chloride and sulphate in water in excess amounts is not desirable. There is relationship between total dissolved solids and chlorides [15]. Its origin is mainly from mineral weathering of bed rocks as well as from anthropogenic source. In the present investigation, the concentrations of chloride and sulphate in the lake ranged 35 - 46 mg/l and 464.86 - 886.52 mg/l respectively. The desirable limit of chloride is 250mg/l and for sulphate, it is 200mg/l respectively.

## CONCLUSION

On the basis of above discussion it is concluded that the effluent discharged from kaolin industry is much contaminated and exceeding the values prescribed by the Standards of Environmental Protection Act , Ministry of Environment and Forests, New Delhi[16], and therefore, it should be treated properly prior to disposal into the environment. The TDS value of the lake water was well above the desirable limit and Dissolved oxygen is ranged from 4.69 – 5.86. This may be due to the low solubility of oxygen in hard and saline water. The waters of the Kanjiracode area were famous for its "karimeen" (pearl spot) and "kanambu" (mullet) fish varieties. Now a days the availability of these varieties has reduced very much. One of the reasons for this reduction may be the changes in properties of lake water as a result of contamination by industrial effluents. Not so long ago, at least 400 families in the area lived off selling "karimeen". Now the fishermen in the area were forced to migrate to areas like Paravur and Varkala in the south.

From the results of the present study it is clear that the lake water used for domestic and agriculture purpose need treatments to attain desired parameters especially for dissolved solids, dissolved oxygen, chemical oxygen demand, alkalinity, iron, and sulphate,. There should be an increasing awareness among the people to maintain the water bodies at their highest quality and purity levels and the present study may prove to be useful in achieving the same.

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