Ecological Degradation of Vattakkayal, a Part of Ashtamudi Lake, Kollam District, Kerala, South India

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Abstract

This study was focused on the variation of physico-chemical parameters in water samples taken from Vattakkayal, a part of Ashtamudi estuary-Ramsar site in Kerala. Water samples from 5 sampling sites in the Lake were analysed for various water quality parameters during the year February 2013- January 2014. The measured water quality parameters were compared with the guidelines proposed by the WHO for drinking water and natural background levels. The results showed that the values of major water quality parameters were higher than the maximum permissible limit of natural background concentrations and recommended values by WHO. The major water pollution threats in the lake were identified as urban and agricultural land uses. This study is believed to assist decision makers in identifying priorities to improve water quality that has deteriorated due to various land uses.

Keywords : *Ashtamudi Lake, Human activities, Pollution, Vattakkayal, Water quality*

I. INTRODUCTION

'Pollution' is the general term associated with unfavorable alterations in the ecology, it cause venomous effects on human health and resources. It is a dangerous and growing process which manifests itself only when the outflow of effluents exceeds the capacity of the receiving ecosystem of environment to recover. Water quality problems have continuous increase around the world because of increased population growth and associated industrial activities. The presence of high levels of pollutants in natural water systems is of major concern because of their potential threats to both human and ecosystem health (Arain *et al,* 2008; Dixit *et al,* 2008; Pamer *et al,* 2008). In fact, 1.8 million people in developing countries, mostly children, die every year from water-related diseases such as diarrhea (Thompson and Khan, 2003; Clasen *et al,* 2007) hepatitis E (Lee and Schwab, 2005), and dental caries and oral hygiene (Ishaque *et al,* 2001). Thus, water pollution is a major public health concern worldwide. Water resources in Kerala have been under increasing threat of pollution in recent years. This is due to inappropriate planning of human settlements that lack suitable sanitary infrastructure, as well as other human activities, including farming activities located very close to water bodies. Various human activities attributable to high population increase within the catchment area of the reservoir have resulted in encroachment of this lake. These activities have generated large volumes of waste water that are discharged into the reservoir. The objective of this study was to assess specific water quality parameters including both physico chemical and heavy metal load in a view to conserve Vattakkayal, a part of Ashtamudi lake.

II. MATERIALS AND METHODOLOGY

A. Study Area

Vattakkayal, a part of Ashtamudi lake in Kollam district, South India is selected as the study area and occupies an area of about 37 acres. Vattakkayal is located at 8°55'3" North latitude and 76°32'57" East longitude, and is about 9 kms away from Kollam Railway Station and located in the Sakthikulangara panchayat. Vattakayal, which is a part of Ashtamudi lake occupies more or less a central position of Kollam with respect to Neendakkara, Kavanadu and Maruthady area. The existing land use of the area consists of water bodies surrounded by marshy vacant land. Previously this low lying vacant land was used for paddy cultivation and the water body is enriched with fish and aquatic life in abundance. At present this kayal is with weeds like water hyacinth as the water body receives domestic wastes, domestic drainages, wastes from nearby factories etc. and is also subjected to many ecological problems. The Vattakkayal also indirectly receives waste water through Kattakkal kayal because it receives waste water discharged from neighboring fish processing unit, ice plants and freezing plants.

B. Sample collection and treatment

Sample containers were thoroughly washed with mild detergent, rinsed with distilled water and dried in an oven. Water samples were collected using spot-sampling equipment. All sample containers and corks were rinsed three times with sample water, filled to capacity, covered immediately with the lid, sealed and labelled. Samples for heavy metals analysis were treated with 2 ml of concentrated nitric acid (HNO_3) to keep the metal ions in a dissolved state and to prevent microbial activities. Water samples for determination of chemical parameters were collected in 1.5 L plastic containers, placed in an ice chest and immediately transported to Department Laboratory, for analysis. Samples were collected seasonally at five different locations from February 2013 to January 2014.

All the physico-chemical parameters of water samples were analysed using standard procedures (APHA, 2012). The concentrations of heavy metals in water samples were determined using an Atomic Absorption Spectrophotometer (Thermo Electron Corporation, S. Series AA Spectrometer with Gravities furnace, UK,) The AAS was calibrated prior to analysis, according to the manufacturer's manual. Recovery value was nearly quantitative (>95%) for all the metals. All the samples were analysed in triplicate, and the average results used to represent the data. Procedural blanks and duplicates were also measured as part of the quality assurance program. Water quality of the study stations has been statistically analysed by using multivariate technique.

C. Software

Statistical calculations, ANOVA was performed by Systat[11] (Systat software Inc., USA), and Excel 2007 (Microsoft corporate, USA).

D. Statistical Analysis

The statistical significance of the data was evaluated by one way analysis of varience [ANOVA]. A value of $P<0.05$ was considered to indicate a significant difference between groups.

III. RESULTS AND DISCUSSION

The water temperatures at five stations were found to be between 27^0C and 33.8^0C. The highest temperature (33.8°C) and the lowest temperature (27°C) were observed at station 4 during pre monsoon and monsoon respectively with a difference of 6.8^OC. Statistical analysis showed that the variations between stations (P= 0.44) and seasons (P=2.25) were not significant.

The values of pH ranged between 6.95 and 8.8. The highest value recorded at station 2 and lowest at station 4. Highest pH value was observed during pre monsoon followed by post monsoon and minimum during monsoon season. There exist significant variations between stations (P=0.86) and seasons (P=6.73). Electrical conductivity (E.C) ranged from 1.35 lS cm^{-1} to 49.39 lS cm^{-1}. Lowest and highest value was noted in monsoon and pre monsoon season at station 1. Variations between stations (P=0.08) and seasons (P=9.27) were not significant.

Total Hardness values varied between 1300 - 4300 mg L^{-1} as $CaCO_3$. The lowest value was recorded in monsoon at station 4 and the highest value at station 3 in pre monsoon. Statistical analysis showed that there is no significant variations between stations (P=0.35) and seasons (P=6.25). Calcium hardness values ranged from 320.6 to 84.7 mg L^{-1} as $CaCO_3$. Lowest value was recorded at station 5 in pre monsoon and highest value was recorded at station 4 in post monsoon season. Variations between stations (P=0.64) and seasons (P=0.08) were not significant. Magnesium hardness values ranged from 97.5 to 804 mg L^{-1} as $CaCO_3$. The lowest value was recorded in monsoon at station 1 and the highest value in pre monsoon season at station 3. Variations between stations (P=0.23) were not significant but seasons (P=0) were significant.

TS values ranged from 100 mg L^{-1} to 40000 mg L^{-1}. The minimum value for total solids (TS) was recorded at Station 1 (100 mg/ I) during monsoon and the maximum in Station 3 (40000 mg /l) during pre monsoon season. Variations between stations (P=0.03) and seasons (P=0.00) were significant. Total dissolved solids (TDS) value ranged from 885 mg L^{-1} to 31000 mg L^{-1}. The minimum value was recorded in station 1 during monsoon and the maximum in station 3 during pre monsoon season. Statistical analysis showed that the variations between stations (P=0.04) and seasons were significant (P=0). Total Suspended Solids (TSS) value ranged from 114.4 mg L^{-1} to 8700 mg L^{-1}. The minimum value was recorded from station 1 in monsoon and the maximum from station 3 in pre monsoon. Variations between stations (P=0.03) were significant but the variations between seasons (P=0.13) were not significant.

The total alkalinity values ranged from 200 to 1020 mg L^{-1} as $CaCO_3$. Lowest alkalinity was noted at station 5 in monsoon and highest at pre monsoon season in station 2. Variations between stations (P=0.18) were not significant but seasons (P=0.01) were significant.

The salinity values ranged from 0.66 to 33.31 mg L^{-1}. Lowest value was noted at station 1 in monsoon and highest value was in pre monsoon season at station 3. Statistical analysis showed that no significant variations between stations (P=0.05), and seasons (P=7.53). Free Carbon dioxide content ranged from 2.8 mg L^{-1} to 13.6 mg L^{-1}. The lowest value was noted at station 1 in monsoon, and the highest value was in second station during pre monsoon season. Variations between stations (P=0.45) and seasons (P=1.11) were not significant. Dissolved Oxygen (DO) content of present study ranged from 1.16 mg L^{-1} to 10.6 mg L^{-1}. Lowest dissolved oxygen was noticed in pre monsoon at station 5 and highest in monsoon season at station 2. There is no significant variations between stations (P=0.91) and seasons (P=2.6).

Sodium content ranged from 342.7 mg L^{-1} to 2183 mg L^{-1}. A lowest and highest concentration was noticed in station 5 and 3 respectively, during monsoon season. ANOVA showed that variations between stations (P=0.11) were not significant but seasons (P = 0) were significant. Potasium concentration varied between 17.2 mg L^{-1} and 205.5 mg L^{-1}. Lowest value was noticed in monsoon (station 5) and highest in pre monsoon season at the stations 4. Statistical analysis showed that there is no significant variations between stations (P=0.15) and seasons (P = 5.29).

The nitrite content of water varied between 0.11 mg L^{-1} and 4.84 mg L^{-1}. Lowest value was recorded at station 2 in post monsoon, and highest value was noted in the same station at pre monsoon season. Statistical analysis showed that the variations between stations (P=0.52), and seasons (P=0.03) were significant. The nitrates content in the water of Vattakkayal ranged from 1.2 mg $L^{-1}$to 30 mg L^{-1}. The lowest concentration of nitrate was noted in monsoon (station 3) and highest value was noted in pre monsoon. ANOVA showed that there exist significant variations between stations (P=0.22) and seasons.

The phosphates concentration ranged between 0.51 mg L^{-1} to 4.86 mg L^{-1}. Lowest value was noticed at station 1 (pre monsoon) and highest at station 4 (monsoon). There is significant variations between stations (P=0.60) and seasons (P=0.20). The sulphates of water ranged from 13.12 to 657.4 mg L^{-1}. The lowest and highest values of sulphates were observed at station 4 during monsoon and pre monsoon season respectively. Statistical analysis showed that the variations between stations (P=0.36) were not significant, but seasons (P=0) were significant.

The concentration of lead ranged from 0.01 to 4.64 mg L^{-1}. Lowest value was noticed at station 1 in post monsoon and highest in pre monsoon at station 4. Statistical analysis showed that the variations between stations (P=0.52) were not significant but seasons (P = 0) were significant. The cadmium content ranged from 0.22 to 1.124 mg L^{-1}. Lowest value was noticed at station 2 in monsoon and highest in post monsoon at station 4. ANOVA showed that variations between stations (P=0.21) were not significant, but variations between seasons (P = 0.01) were significant.

The concentration of copper ranged from 0.08 to 0.45 mg L^{-1}. Lowest value was noticed at station 2 and 4 in monsoon and highest in post monsoon at station 3. Variations between stations (P=0.21) and seasons (P = 0.08) were not significant. The concentration of iron ranged from 1.17-13.84 mg L^{-1}. Lowest value was noticed at station 1 in monsoon and highest in pre monsoon at station 3. There exist is no significant variations between stations (P=0.10) but the variations between seasons (P = 0) were significant. The chromium content ranged from 1.17 to 13.84 mg L^{-1}. Lowest value was noticed at station 2 in monsoon and highest in pre monsoon at station 1. Variations between stations (P=0.88) were not significant but seasons (P = 0) were significant.

Table 1: The range means and standard deviations of physicochemical water parameters of Vattakkayal, as compared to natural background concentrations and recommended values by WHO.

Parameter	Mean	WaterResources Commission (WRC 2003)	WHO (2011)
pH	7.4	7	.5–8.5
Temperature (°C)	29.7	22-29	NA
Electrical conductivity (lS cm-^{1})	22.0	50-300	1000
TDS (mg L^{-1})	12496.2	NA	500

Alkalinity as $CaCO_3$ (mg L^{-1})	552	NA	200
DO (mg L^{-1})	6.0	7	NA
Total Hardness as $CaCO_3$ (mg L^{-1})	2626.6	NA	500
Ca Hardness as $CaCO_3$ (mg L^{-1})	526.3	12	75
Mg Hardness as $CaCO_3$ (mg L^{-1})	326.4	NA	30
Nitrites (mg L^{-1})	2.9	NA	3
Nitrates (mg L^{-1})	10.4	0.23	50
Phosphates (mg L^{-1})	2.1	0.02	<0.3
Sulphates (mg L^{-1})	287.1	0.1-10	250
Fe (mg L^{-1})	5.2	0.67	0.3
Pb (mg L^{-1})	2.0	0.005	0,01
Cu (mg L^{-1})	0.2	0.007	2

Physico-chemical water parameters of Vattakkayal were compared to natural background concentrations and recommended values by WHO standards are shown in **Table 1**. The results show that major water quality parameters were higher than the maximum permissible limit of natural background concentrations and recommended values by World Health Organisation. Water in Vattakkayal was observed to contain high concentrations of TS, TSS, TDS, chromium, conductivity, salinity, sodium, potassium, phosphates, cadmium, iron, sulphates, calcium, temperature, and copper therefore not being suitable for human consumption and recreational purposes without treatment. It is important, therefore, that people using non-treated water from the lake for domestic and agricultural activities must be warned of the imminent dangers that can result from its use, including common diarrhoea, ear infections and such deadly water borne diseases such as cholera, hepatitis and typhoid fever. Based on the analysis results, it may be concluded that the main parameters responsible for water quality variations observed in Vattakkayal were mainly soluble salts, organic pollutants and nutrients released from anthropogenic sources.

IV. CONCLUSION

Water in Vattakkayal was observed to contain high concentrations pollutants therefore not being suitable for human consumption and recreational purposes without treatment. It is important, therefore, that people using non-treated water from the reservoir for domestic and agricultural activities must be warned of the imminent dangers that can result from its use, including common diarrhoea, ear infections and such deadly diseases as cholera, hepatitis and typhoid fever. Furthermore, it could also provide basic guidelines for designing possible preventive measures for managing water resources. Based on the results of the present study, it is recommended to take urgent steps to bring back this ecosystem from its polluted state.

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