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Assessment of eutrophication in lakes: Retrospective analysis

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Abstract: Surface water temperature, pH, and BOD_5 did not differ among the Lakes while DO, TDS, alkalinity, TH, and concentrations of phosphate and nitrate were considerably higher in urban and peri-urban Lakes and the increase was more than two-fold in the case of major ions and tenfold in the case of nutrients concentrations in urban and peri-urban Lakes compared to rural Lakes, indicating a decline in water quality. Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD) were higher in peri-urban Lakes compared to urban and rural Lakes. When located in densely populated areas, lakes may become polluted by inadequately treated, or untreated, human and animal wastes. This causes eutrophication, makes the water unfit for human consumption and increases health risks to water users. Velachery Lake is one of the lakes inside Chennai, in the Indian state of Tamil Nadu, with a good stock of water all through the year. The area under study is a low-lying area, the monsoon rain water from the surrounding areas are drained into this lake. The water is totally contaminated and not conducive for boating. The rapid pace of real estate development in the last two decades resulted in the shrinking of the water body from 265 acres to 55 acres now. One of the few fresh water lakes left in the city, the lake has suffered due to misuse by residents from the locality and dumping of garbage by government agencies in addition to letting untreated sewage water into it. This paper aims in studying and analysing the water quality if the lake under consideration and provide suggestions to improve and sustain the water resources meeting various demands.

Keywords: Eutrophication, Alkalinity, Contamination, Nutrients.

1. Introduction

Lake Velachery is one of the prime lakes situated amid the metropolitan city of Chennai in Tamil Nadu. This is an artificial lake created in 1988-89. It is one of the lakes with a good stock of water all through the year. Since Velachery is a low-lying area, the monsoon rain water from the neighbouring areas is drained into this lake. In an unexpected turn of events, the Chennai Corporation has decided to put on hold the proposal for boat rides and other tourist facilities on the Velachery Lake, one of the few water bodies still alive in the city. The reason it has cited is the high level of contamination of the water. are also about 2,000 families living in the southern bund. The lake, which once spread over 100 acres, has been reduced to half that size due to encroachments, conversion of residential plots by Tamil Nadu Housing Board and paving of roads**.** There are about 2,000 families living in the southern bund. Even though some have toilets in the backyard, they conveniently direct the pipelines to the lakeWastes high in organic matter directly increase the chemical and biological oxygen demand in the receiving waters. This results in localised areas of oxygen depletion and the release of many trace elements by the reduction of iron.

Water quality of the Lake showed a gradient in response to the urbanization process; with severe changes being noticed in urban and peri-urban Lakes, most often obliterating seasonal patterns normally present in small water bodies, while fewer changes were noticed in rural Lakes. However, BOD5 did not show relatively wider variations among the Lakes. Significant differences in TDS among the Lakes can be seen which varied from 399 to 542 ppm in rural Lakes to a higher range of 763 (WIN) to1401 (SWM) ppm in peri-urban Lakes. In urban and peri-urban watersheds, concentrations of both inorganic and organic pollutants including faecal bacteria may have been higher, which might have further been exacerbated by rainfall, leading to a significant but unquantifiable dissolved and suspended load added to the receiving water bodies. The high mineralization and increased concentration noticed in the case of Velachery Lake may be due to this phenomenon. The pH indicated a neutral range of 7 to a mildly alkaline value of 8.5. Increase in pH was noticed in urban Lakes during SWM season (8.24) while a decrease in seasonal average can be seen in rural Lakes. Surface water pH of the unpolluted Lake is generally connected to the carbonate system (Wurts and Durborow 1992) but enhanced photosynthetic activity by algae which use

free carbon dioxide in summer, with increase in temperature and transparency, may have increased the pH in urban Lake.

2. Literature review

Archana Gupte et.al (1970), deals with the physio-chemical properties of bottom sediment of a fresh water lake in which fishing is carried out. The soil of the lake under study was found to contain 35 % sand followed by 25% silt and 40 %clay. Thus, the bottom soil was clayed loam in texture. The colour of the soil was black. The pH, conductivity, organic carbon, inorganic phosphate and nitrate were measured seasonally for two years. The water retention capacity of soil was observed as 47 % indicating favourable condition for fish culture practices as well as the chemical parameters which were complementary to it. The loose unconsolidated top layer of earth crust is called soil. It is a site of decomposition of organic matters and mineral materials. Lake soil has several roles to play, especially in the production of fish in the lake. The bottom sediment according to Matida (1968), is important as it supplies essential nutrients to the inflowing water as also in the mineralization of organic sediments and in the storage and release of nutrients in the water. The soil is the chief sources of nutrients for primary producers.

Hussain Sagar et.al (2002), Lakes sediments consists of biological and non-biological matter accumulated since from formation of the lake. Sediment sequence in lake represents information about the activities within the lake and in its catchment area over a period since its inception. Hussain Sagar Lake located in the heart of Twin Cities of Hyderabad and Secunderabad receives toxic substances from the industrial effluent discharges in to it through incoming nallas. Pollutants entering the lake undergo either absorption or adsorption by fine particles present in the lake water, which may in turn settle down in the form of sludge. The sludge is further classified into pore water and sediments. This paper aims to explain the Physio-chemical characteristics of sediments and pore water of Hussain Sagar Lake. The experimental results show that the mean value of organic content in sediment is 5.6% with almost 100%settlement of suspended particles in the detention time of about 317 days. Higher pollutant concentrations observed in sediments and pore water is attributed to accumulation of pollutants generated in the catchment area and transported through inlet nallas in to the lake. The concentrations of heavy metals like Chromium and Lead have shown relatively elevated over a period of one decade.

Amir Abdullah et.al (2009), Water pollution is one of the major global environmental problems. It is an acute problem almost in all major river sand water reservoirs in India. Water pollution is increasing and becoming severe day-by-day and posing a great risk to human health and other living organisms. There is growing concern on the deterioration of ground water quality due to geogenic and anthropogenic activities. Present investigation aims at insight about the level of contaminants of surface water, groundwater and sediment analysis of selected locations of Pavana river of Pimpri-Chinchwad area of Pune district. An attempt has been made to assess the water quality, sediment and weed analysis of the samples. A higher value of TDS was observed at groundwater site G4 with 834.27 mg/l while it was lower at surface water site 1 by 65.12 mg/l. Dissolved oxygen content of the water samples was observed quite well in limit, but it was lower with 1.6 mg/l at surface water site 4 while higher at surface water site 2 with 5.23 mg/l. In the present study, highest value of COD was observed by value of 120 at surface water site S4 while was lowest with only 64 mg/l at groundwater site G4. As expected groundwater samples showed higher values of hardness content as compared to surface water samples of Pavana river. Nickel content was found to be present at all sites with a range of 22 to 40 mg/kg. There is urgent need for more representative samples to be used to go beyond preliminary assessment as reported in the present study for making appropriate recommendations.

Mehdi Delphi et.al (2013), Shoushtar city is a coastal one why includes a big part of the Karun river and has many water uses; so the crevasse canal of the Gar-Gar as an artificial and manmade branch of the Karun, the biggest river in Iran, and in Shoushtar domain is started in place of the setting dam, Band-E-Mizzan, and it devotes 0.1(according to seasonal measurements averaged) of water volume flowing in the Karun route before the setting dam controlled by the 9 setting windows on the dam. Water current as volume of water, transport water and so sediment particles to other places in route of river canal. Widespread currents through width of river canal transport sediments and coastal erosion in coast lines that are influenced by topography and steepness of river canal. In this research after continuous and regular measurements in two warm and cold seasons (winter and spring of 2009) and comparing with the data collected by zonal water and electricity organization, Khuzestan state (for calibration of the measurements), contours of dominant current in the river width and widespread current with

measured current spectrum around the setting dam will be drawn, then effective factors in forming dominant currents will be appointed there. The effective factors on destructiveness of currents in coastlines of the river with a meander in it will bean applied and useful result.

Mahmud Hassan et.al (2009), The pollution of river water and sediments by heavy metals has assumed serious problems due to their toxicity and accumulative behaviour. The present study has been undertaken to assess the levels of heavy metals and the extent of pollution in the surface water and sediments from the Meghna River. Water and sediment samples were collected by the Standard Methods and, processed and analysed for heavy metals using Flame Atomic Absorption Spectrophotometer (FAAS). The mean concentrations of heavy metal found in the river water were in the order of: Fe (1.0224 mg L−1) > Zn (0.0364 mg L−1) > Cr (0.0346 mg L−1)>Mn (0.0088 mg L−1) > Cd (0.003 mg L−1) and in the sediments in the order of: Fe (1281.416 mg kg−1) >Mn (442.596 mg kg−1) > Zn (79.021mg kg−1) > Ni (76.116 mg kg−1) > Cr (31.739 mg kg−1) >Pb (9.oping countries like China. The assessment of water eutrophication has been advanced from simple individual parameters like total phosphorus, total nitrogen, etc., to comprehensive indexes like total nutrient status index. The major influencing factors on water eutrophication include nutrient enrichment, hydrodynamics, environmental factors such as temperature, salinity, carbon dioxide, element balance, etc., and microbial and biodiversity. Water eutrophication can also cause the super saturation or lack of dissolved oxygen in water, which will be dangerous to aquatic animals and cause great death to them. Eutrophic systems tend to accumulate large amounts of organic carbon causing a shift in organic matter biochemical composition meanwhile, because of water eutrophication, a mass of algae, mainly Cyanophyta and green algae, bloom and form a thick layer of “green scum” on water surface. Algae can release toxins and render the organic matters in water to be decomposed into harmful gases, which will poison the fish and seashell. Water eutrophication is mainly caused by excessive loading of nutrients into water bodies like N and P. Excessive nutrients come from both point pollution such as waste water from industry and municipal sewage, and non-point pollution like irrigation water, surface run water containing fertilizer from farmland, etc. Eutrophication is not likely to occur if both TN and TP in water are low, but eutrophication may not occur in water high in TN and TP if other conditions such as

temperature and current speed are not favourable.

John G et.al (2013), River Noyyal is major tributary of River Cauvery has been one of the most prominent and important rivers of Tamil Nadu. Unfortunately, certain stretches of river Noyyal are much polluted in industrial and urban waste. The present study analyzed the pollution level of Noyyal River with a view to create a database on the zone-wise pollution level of the river. Samples were analyzed for a period of one year from July 2008 to June 2009 in five sampling points at Noyyal River. Totally, 23 physiochemical parameters were analyzed in five sampling locations of the river. Orathupalayam dam area recorded higher concentrations of pollutants than the permissible limits, and the lowest concentration was noted at Chadivayal. Totally six heavy metals Cr, Zn, Cd, Cu, Pb and Hg were observed in all the sampling points. Linear combinations of environmental factors, including heavy metals were subjected to Principal Component Analysis (PCA). All the physiochemical and heavy metals are observed in maximum to permissible limit. Results indicate that Noyyal river is moderately polluted under the study area.

Amir Abdullah et.al (2003), A lake may be defined as an enclosed body of water (usually freshwater) surrounded by land and with no direct access to the sea. Lakes are sometime subjected to wastewater discharges originating from different sources. Chemicals such as nitrogen, phosphorus and carbon in certain concentration might distort and disrupt aquatic ecosystem. Eutrophication of inland water bodies has become synonymous with the deterioration of water quality, which interferes with most of its beneficial uses. Now a day's many human activities create the pollution in and around the water body, due to which natural status of lakes may come in the danger zone of water pollution. The quality of water usually is described according to its physical, chemical and biological characteristics. Rapid industrialization and indiscriminate use of chemical fertilizers and pesticides in agriculture are causing heavy and varied pollution in aquatic environment leading to deterioration of water quality and depletion of aquatic biota. Due to the use of contaminated water, human population suffers from water borne diseases. It is therefore necessary to check the water quality at regular intervals of time. This review paper gives a brief overview about lake, its classification and the various factors affecting its water quality. Moreover, problem of eutrophication is also discussed in detail. Various parameters required for analyzing water

quality along with water quality index are also discussed.

Payal K. Baitule et.al (2007), Nature is changing its form day by day. Due to change in natures form, the quality of environment is depleting day by day. Environment mainly depends on the air & water. Water in the river exposes to environment during flowing and passes through various regions &may result in carrying polluted water. Water quality of river is deteriorating day by day due the wanted & unwanted activities of the human being. Most of the rivers in India are severely polluted due to anthropogenic activity which is of serious concern. In this project the water quality of Nag River of Nagpur in Maharashtra, India is determined. Recently various endless efforts are being made to bring Nag River into city's heritage list. This river flows across the city and serves as waste water carrying drainage for city of Nagpur. Its ecosystem is extremely polluted by urban waste pollution from Nagpur. All metabolic, physiological activities & life processes of aquatic organism are generally influenced by such polluted waste & hence it is essential to study physio-chemical characteristics of water. The wastewater will be analysed for the main water quality parameters such as temperature, pH, colour, dissolved oxygen, conductivity, turbidity, total dissolved solids. The effluent samples will be collected from five different locations

R. Lodh et.al (2003), Present work was designed to study the physicochemical parameters of four lakes of Udaipur known as the "City of Lakes" of Tripura state. The studied lakes are Amar Sagar (AS), Dhani Sagar (DS), Jagannath Dighi (JD) and Mahadeb Dighi (MD). To evaluate the water quality of the lakes and to identify the pollution sources random sampling was done during the month of April 2014. Collected samples were analysed according to APHA (2005) for different physicochemical parameters and the results were compared with standard values prescribed by WHO (1997) and BIS (1991). Obtained results of physicochemical water quality parameters of studied lakes revealed the fact of pollution load in the lakes. Average Biochemical Oxygen Demand (BOD) as well as the value of ammoniacal nitrogen (NH3-N) is found high during analysis which conveys high bacteriological load, organic matter disposal and animal waste contamination into the lakes. The main pollution sources are identified as, four numbers of canals flowing municipality waste into the AS and one in DS, organic waste disposal into the lakes by residents, agriculture practice inside the AS during dry season and contamination of domestic

waste from run over drains in various parts of different lakes. Consequences of such human activities and discharge of sewage water makes the existence of the lakes more vulnerable. It is the prime necessary to take immediate remedial action to prevent all anthropogenic activities in the studied lakes or else the lakes will become biologically barren and will be lost forever.

Joseph Clement et.al (1999), the purpose of this research is to determine the levels of some physicochemical parameters in water and sediment samples from Kwantanturare in Lake Chad, Baga, Borno State, Nigeria. Water samples were collected from five points designated as S1 to S5 for the determination of biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO) total dissolved solid (TDS), total suspended solid (TSS) anions and trace element. Sediment samples were also collected for the determination of heavy metals and total organic carbon (TOC). These parameters were determined using approved standard procedures. The levels of heavy metals in the water and sediment samples were determined using atomic absorption spectrophotometer (AAS). The concentrations of DO, BOD, COD, TSS, TDS, TOC, nitrite, nitrate, Phosphate, Sulphate, and Chloride in the water samples from the five-sampling point were higher than the WHO limits for the protection of fish and other aquatic life. The concentrations of Fe, Mn, Cu, Cd, Pb, Ni and Co in the water samples were higher than the WHO guideline limits, indicating severed pollution of this portion of Lake Chad. This high level of heavy metals in the water samples is expected owing to runoff of wastewater from agricultural activities within the study area.

Manohar et.al (2002), Heavy metals concentrations in Nairobi dam water were analyzed between the wet and dry seasons. Water samples were collected once in a month from seven sampling sites within Nairobi dam, these samples were preserved, stored and analyzed for heavy metals: Copper (Cu), Cadmium (Cd), Lead (Pb) and Nickel (Ni) concentrations using an Atomic Absorption Spectrophotometer (APHA). The sequence of heavy metals accumulation in dam's water was: Pb> Cd > Cu > Ni, these metals mean values during the dry vs. wet seasons were: 16.78±0.21 vs 11.67±0.21; 5.12±0.18 vs 3.76±0.15; 4.90±0.25 vs 2.99±0.05; 2.11±0.12 vs 1.20±0.13mg/L respectively within water of Nairobi dam. These levels of heavy metals in this dam are higher than maximum permissible levels by WHO, EU and KEBS for drinking water. The outlet water had significantly lower metals

contamination in comparison to the inlet waters of the dam ($p \leq 0.006$) during the wet than dry season. It is concluded that higher levels of heavy metals concentration in the dam`s water is in the dry than wet season ($p < 0.0001$). Based on water analysis data it is recommended that the water of this dam is not suitable for human consumption and even for agricultural activities

Nibedita guru et.al (2015), Oxygen-demanding substances are major contaminants in domestic and municipal wastewater. The main indicators of river pollution which deals with the oxygen domestic conditions of the river are Biochemical oxygen demand (BOD) and dissolved oxygen (DO). To manage the quality of natural water bodies that are subjected to pollutant inputs; one must be able to predict the degradation in quality that results from such inputs. The non-point source pollution is another imperative variable responsible for increasing pollutant load in a stream/river. Recognizing the magnitude of assessing non-point source pollution in river system, copious studies intended at understanding the processes controlling nutrient concentration, fluxes in the river systems and the quantification of the nutrient loads of rivers have been proficient in past. Most commonly used BOD-DO model has been used to simulate the point source pollution at different reaches of Mahanadi river system lying in Odisha and model parameters deoxygenation coefficient (k1) and reaeration rate coefficient (k2) have been established. Various empirical equations used for estimating and reaeration rate coefficient were used and a modified equation suitable for estimating reaeration rate coefficient has been derived.

M.Jaikumar et.al (2008), Population increase in the last 50 years Chennai with current population of4,681,087 (4.6 million) is one of the largest cities of South India. The Population density of Chennai is 26903, which is currently largest in the state of Tamil Nadu. Chennai has witnessed a tremendous growth in its manufacturing, retail, health care and IT sector in the last 10 years., The fast growth of population has caused rapid in increase the domestic sewage pollution This present study deals with the wastewater sewage discharge to the Velachery lake near southern Chennai. It is proposed to control the pollution through water hyacinth (Eichhornia Crassipes). Phytoremediation considered the best technology to solve the sewage pollution. The main objectives of the study are to reduce the sewage effluents load in the lake by a continuous phytoremediation process using E.

Crassipes and second use the lake eco-friendly for Aquaculture and Tourism.

Srajan Shrivastava et.al (2016), the project was based on testing the quality of water. Three different samples were collected from 'KantajharBasti' situated behind the campus of NIT Rourkela from three different tube wells at two different times of the year. The first set of samples was collected after the rainy season in the month of September 2013. And the second set was collected in April 2014.Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water.

Trivedi R.K et.al (2013), The fate and effect of different pollutants entering the estuaries can be obtained from the existing physio-chemical parameters and it is worthwhile to acquire the hydrographical features of the estuaries at different seasons. This determines the tropic dynamics of the water body. The present study has been made to detail the hydro-geo dynamics of Poonthura estuary. Sewage and retting materials were the main sources of Poonthura estuary. The physio-chemical parameters analysed include temperature, pH, salinity and alkalinity and dissolved oxygen. The toxic gases hydrogen sulphide, ammonia nitrogen and nutrients viz. nitrite-nitrogen, phosphate phosphorous and silicate-silicon of water samples and the sediment parameters viz., organic carbon, total nitrogen, total phosphorus. From the present study the parameters which are unsuitable for the healthy environment increases during pre-monsoon due to concentration of pollutants. The winter season showed fewer nutrients with normal level of dissolved oxygen.

Shivaji Jadhav et.al (2016), deals with the study of Chloride concentration of Nira River in the year 2016. Fresh water is essential to existence of life. Acceptable quality water is essential not only for drinking and domestic purposes but also for agriculture, industrial and commercial uses. Chloride occurs naturally in all types of water. In natural fresh water, the concentration is quite low. The important source of chloride in the water is the discharge of domestic sewage. Chlorides are highly soluble in water, so they do not get precipitate and cannot be removed by biological treatment of water. If the

amount of chloride is beyond the permissible limit, then it can corrode by extracting calcium in the form of calcite. Here in the present work the amount of chloride observed is within the permissible limit for Nira river.

Shouliang Huo et.al (2011), The characteristics of organic phosphorus (Po) fractions in the sediments of nine lakes from the middle and lower reaches of the Yangtze River region, Yungui Plateau, Qinghai–Tibet Plateau, Northeast-China Region, and Mongolia–Xinjiang Plateau, China were investigated and the differences of the different lakes on P fractionation was discussed. The results indicated that organic matter (OM) showed significant positive correlations with Po in sediment samples, and the rank order of the Protractions was: residual Po > HCl–Po > fulvic acid–Po > humic acid–Po > NaHCO3–Po with mean relative proportions 7.4: 3.4: 2.4: 1.7: 1.0. The labile and moderately labile Po were the main fractions in the sediments for shallow eutrophic lakes except for Lake Qilu, however, non-labile Po was dominant in the sediments from deep lakes. Labile Po was significantly correlated with total phosphorus (TP), inorganic phosphorus (Pi), Po, NaHCO3–Pi, HCl–Pi and NaOH–Pi, and the non-labile Po was significantly and positively related to OM, TP, Po and NaOH–Pi.

R John Morrison et.al (2013), summarizes the main extraction methods for sedimentary phosphorus (P) determination. With sequential chemical extractions, P is supposed to be selectively removed from different compounds in the sediments. Extraction schemes using strong acids and alkaline solutions have been tested on different sediments and found not to extract well-defined fractions. In addition, several systematic errors in these schemes have been detected. Thus, these schemes have been modified and simplified accordingly. The Standards Measurements and Testing Program of the European Commission (SMT) method is a popular modification of these extraction schemes, as it is simple to handle, allows laboratories to achieve reproducible results and could provide a useful tool for routine use by water managers. The SEDEX (sequential extraction method) method, another popular modification, is widely applied in biogeochemical research as it can separate authigenic carbonate fluorapatite from fluorapatite. Other chemical extractions using chelating compounds have attempted to extract P bound with iron and calcium in sediments without disturbing clay bound or organic P, the purpose being to determine the

algal-available non-apatite, apatite and organic fractions of sediment P. All extraction procedures still yield operationally defined fractions and cannot be used for identification of discrete P compounds. Future modifications of the extraction scheme should aim to achieve better extraction efficiency and selectivity, simple handling techniques and methods that can prevent the extracted P from being re-adsorbed onto Fe (OOH) and CaCO3.

G. J. Chakrapani et.al (2006), Kumaun Himalayan lakes, situated in the state of Uttarakhand, are one of the major tourist attractions in northern part of India. Present study is aimed to understand the behavior of phosphorus in lake sediments and different chemical forms of phosphorus in sediments. The study was accomplished by collection of core sediments from lakes. The core samples were analyzed for major oxides, nutrients, and phosphorus fractionation. The study shows that lake sediments are derived from catchment rocks. Total concentrations of nutrients (P, N, and S) in sediments varied differently and are derived from both natural and anthropogenic activities. Phosphorus in sediments is sequestered more by calcium than iron and aluminum oxides, as carbonate flour apatite. Fractionation study shows that phosphorus as carbonate flour apatite and in-exchangeable fraction. The dissolution of organic matter results in release of phosphorus from sediments. The study also shows biogenic silica and sulfate act as major competitors of phosphorus for sorption sites of iron oxides resulting in the release of phosphorus from sediments. Based on the findings, the Meghna river water can be considered as unpolluted with respect to Cd, Cr, Mn and Zn, whereas concentration of Fe was above the standard value according to recommended standard guidelines. According to Sediment Quality Guideline (USEPA, 1989), sediments were not polluted for Cd, Pb and Zn; moderately polluted for Cr and Mn and heavily polluted for Ni.

3. Conclusion

In this paper effect of phosphorus is varied through the lake. We attribute these significant lower phosphorous levels to ground water can be a main cause of eutrophication of lake water sources, especially when a contamination leads to high nutrient concentrations in those parts of the shoreline where main lacustrine in those parts of the shore line where main Lacustrine Groundwater discharge (LGD) takes place.

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