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Water Quality Analysis of Manimala River and Its GIS Modelling

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WATER QUALITY ANALYSIS OF MANIMALA RIVER AND ITS GIS MODELLING

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Abstract Water is the basic element of social and economic infrastructure and is essential for healthy society and sustainable development. Determination of water quality ensures the usability of water for various purposes. Water with good quality ensures safety for drinking and safeguards public health. Due to rapid increase in density of population, fast urbanisation, industrialisation and agricultural, use the demand of water is increasing day by day.as a result, surface water level is decreasing, pollution and increased demand have made good quality water scarcer and more expensive. So monitoring of surface water quality has become indispensable. GIS not only facilitates data capture and processing but also serves as powerful tool that facilitates multimap integrations. In this project water quality analysis was carried out for Manimala River and samples are taken from 30 stations all around the district, Kottayam, Pathanathitta, Alappuzha and mapping done with GIS based water quality mapping.

Keywords Water Quality – GIS – Analysis - Manimala River

I. INTRODUCTION

Water is perhaps the most precious natural resource after air. Though the surface of the earth is mostly consists of water, only a small part of it is usable, which makes this resource limited. This precious and limited resource, therefore, must be used with care. As water is required for different purposes, the suitability of it must be checked before use. Also, sources of water must be monitored regularly to determine whether they are in sound health or not. Poor condition of water bodies are not only the indictor of environmental degradation, it is also a threat to the ecosystem. In industries, improper quality of water may cause hazards and severe economic loss. Thus, the quality of water is very important in both environmental and economic aspects. Thus, water quality analysis is essential for using it in any purpose.

Water Quality can be defined as the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use. Water can be used for recreation, drinking, fisheries, agriculture or industry. Each of these designated uses has different defined chemical, physical and biological standards necessary to support that use. For example, there are stringent standards for water to be used for drinking or swimming compared to that used in agriculture or industry.

Modelling of water quality in river manimala was done using GIS software. Geographical information system (GIS) used for variety of application from micro-level planning to macro-level planning, implementation and regular monitoring. The GIS is rapidly growing field of research with an integration of different subjects from atmosphere to ocean, land, sea, water resources, health, defence, agriculture, demography, forestry to economics and many more.

GIS is defined as a technique to capture, store, retrieve, analyse and predict. GIS is also used as database system to store and prepare 2D, 3D or 4D water quality status maps according to concentration values of different chemical constituents. GIS is a helpful tool for developing solutions for water resources problems to access water quality, determining water availability and understanding the natural environment.

II. MATERIALS AND METHEDOLOGY

I. Study Area

Manimala river has its origin on the muthuvara hills (2500 feet above main sea level) in the western ghats,in idukki district of kerala. The river passes through the districts of kottayam,pathanathitta and finally joins the pamba river at muttar near thiruvalla in Alappuzha district. Yendayar, Koottickal, Mundakayam, Koratti, Chennapaddy, Manimala,Erumeli, Kottangal, Kulathurmoozy, Vaipur, Mallappally, Keezhvaipur, Thuruthicad, Kuranjoorkadavu, Kallooppara, Vallamkulam, Kuttoor ,Pulikeezh, Nedumpuram, Neerettupuram, Amichakary, Muttar, Kidangara, Pulincunnoo, Veliyanadu, Ramankary, Mankompu lie on the banks of Manimala River. Manimala splits after Kidangara into two branches. Second branch flows via Kunnamkary, Kavalam and Kainakary to Vembanad lake. Its running length is estimated at 92 km. It empties itself into the Vembanad Lake. It is one of the four major rivers which do not have direct outlet to sea as these rivers (Meenachil, Pamba, Manimala, Achankovil) empty into the vast Vembanad lake.

II. Sampling and data collection

The collections were made during day time. 30 sampling locations are selected based on the area which may have a higher rate of pollution. The surrounding areas of the sampling locations are studied.Maximum care was taken for the collection of samples, their preservation and storage as per the APHA standards. Latitude and Longitude of the sampling stations are also marked by using GPS. The results are compared with the standard values and the quality of water at different locations are analysed.

III. Physio-chemical parameters

Water contains different types of floating, dissolved, suspended and microbiological as well as bacterial impurities. Some physical test should also be performed for testing of its physical appearance such as temperature, colour, turbidity, pH, etc. while chemical tests should be performing for its BOD, COD, DO and other characters. Manimala River was chosen for the study. A network of 30 sampling stations along the Manimala River was selected for the water quality studies. Following physical, chemical and biological parameters are tested for monitoring quality of water. They are PH, Total Dissolved Solids, Hardness, Dissolved Oxygen,Biochemical Oxygen Demand, Chemical Oxygen Demand, Turbidity, Chloride, Sulphate, Alkalinity And Acidity, Test For MPN.

PH

PH is the negative logarithm of Hydrogen ion concentration in water, in moles/ litre at a given temperature..ie $pH = -\log[H^+]$.pH (6.5-8.5) has no direct effect on health, however a lower value below 4 produces a sour taste and a higher value above 8.5 a bitter taste. High pH induces the formation of tri-halomethanes, which are causing cancer in human beings. The test is done as per IS 3025 part 11. Standardize the pH meter using Buffer solution. Clean the electrode using distilled water and wipe off. Insert the electrode in the sample. Wait for a steady reading. Note the pH.

Chemical Oxygen Demand (C.O.D)

Chemical oxygen demand (C.O.D) is the amount of oxygen required for decomposition of biodegradable and non-biodegradable organic matter. C.O.D test is widely used as a means of measuring the pollution strength of domestic and industrial wastes. The test is done as per IS 3025 Part 58. Take 10 ml of sample in a refluxing flask. Add 1 gm. Mercuric sulphate and a few glass beads .Add 15 ml H_2SO_4 to dissolve the mercuric sulphate and cool. Add 15 ml 0.25N $K_2Cr_2O_7$ solution and mix well. Attach the flask to the condenser and start the cooling water. Apply heat and reflux for 2 hours. Cool and wash down the condenser with distilled water. Cool to room temperature. Titrate the excess dichromate with standard 0.1 N Ferrous Ammonium Sulphate (FAS) solution using ferroin as indicator. The colour change from blue green to reddish brown indicates the end point. Note the volume of FAS consumed (B mL).

Reflux a blank (distilled water) of equal volume in the same manner and note the volume of FAS consumed (A mL).

COD of the given water sample, mg/l = ((A-B) xNx8x1000)/V x DF

Where,

A=Volume of FAS consumed for the blank, mL

B=Volume of FAS consumed for the sample, mL

N=Normality of FAS

D.F=Dilution Factor=Total volume of the diluted sample/ volume of undiluted sample taken for dilution

V=Volume of the sample taken, mL

Equivalent weight of O_2=8g

Total Dissolved Solids

Total solids is the term applied to the material left in the vessel after evaporation of a sample of water or waste water and its subsequent drying in an oven at a definite temperature. Total solids include total suspended solids the portion of total solids retained by a filter and total dissolved solids the portion that passes through the filter. The test is done as per IS 3025. Ignite the clean evaporating dish in the muffle furnace for 30 minutes at 550 0C and cool in a desiccator. Note down the empty weight of the dish (W1). Filter a measured portion of the mixed sample (50 or 100) through a filter paper and collect the filtrate in a previously prepared and weighted evaporating dish. Transfer the dish to an oven maintained at either 103-1050C or 179-181 0C and dry it for one hour. Allow the dish to cool briefly in air before placing it while still warm, in a desiccator to complete cooling in a dry atmosphere. Weigh the dish as soon as it has completely cooled (W2).Weight of residue = (W2 - W1) mg.

Mg/l of Total Dissolved Solids (TS) = (W2-W1)mg)/(V ml) X 1000

Dissolved Oxygen

In liquid wastes Dissolved Oxygen is the most important factor in determining whether aerobic or anaerobic organism carryout biological changes. If sufficient D.O is available aerobic organisms oxidize the wastes to stable products. If D.O is deficient anaerobic bacteria take part in the conversion and reduce the waste often to obnoxious and nuisance conditions are usually resulted. The test is done as per (IS 3025 Part 38). Fill the given water sample in a glass stoppered 300 ml BOD bottle. Be careful to avoid contact of the sample with air. The bottle should be completely filled. Immediately after filling the BOD bottle add 2 ml of $MnSO_4$ solution by means of a pipette, dipping the end of the pipette just below the surface of water. Add 2 ml of Azide Alkali potassium iodide in a similar manner. Insert the stopper with care to exclude air bubbles and mix by repeatedly inverting and shaking the bottle vigorously. Add 2 ml of

concentrated H2SO4 to the bottle. Red precipitate will form if D.O is present in water. Allow the precipitate to settle. Insert the stopper at once and mix thoroughly as before. Allow the solution to stand for at least 5 min to ensure the formation of iodine, which is to be titrated against sodium thiosulphate.Withdraw 101.5 ml of the solution and titrate with standard sodium thiosulphate solution to a pale yellow colour. Add 1-2 ml of starch solution. This will give blue colour. Now, continue the titration to the first disappearance of blue colour. Record the volume of thiosulphate added (A ml).

D.O in mg/l = (A*N*8*1000)/V

Where,

A = Volume of Thiosulphate used, ml

N= Normality of Thiosulphate used

V =Effective Volume of sample taken, mL= 300/(300-4)*100 = 101.5 ml

Equivalent weight of O2 = 8g

Biochemical Oxygen Demand (Bod)

The BOD of polluted water is the amount of oxygen required for the biochemical decomposition of biodegradable organic matter to occur under aerobic conditions and at a standardized temperature and time.BOD test is used to determine the strength of domestic sewage, industrial sewage and other polluted water. The test is done as per (IS 3025 Part 44). Fill the water in two sets of BOD bottles. Determine the initial dissolved oxygen of sample in one set bottle (D1 mg/L).Keep the other set for incubation at 200C for 5 days. Fill the water alone in two BOD bottles. Find the DO of the water in one bottle (B1 mg/L).Keep the second bottle filled with water in incubator for 5 days at 200C.Determine the dissolved oxygen in incubated sample and blank bottle after 5 days.

BOD of the sample=Initial DO-Final DO (after incubation)

Turbidity

Turbidity is the measure of the extent to which light is scattered or absorbed by suspended materials in water. Absorption and scattering are influenced by both size and surface characteristics of the suspended matter. Turbidity is not a direct quantitative measurement of suspended solids. The most commonly used method for the determination of turbidity is nephelometric method. The test is done as per (IS 3025 Part 10). Calibrate the nephelometer according to the instructions given in the manufacturer's manual (Insert the turbidity free distilled water and set the reading to 0. Insert 40 NTU standard and set reading to 40 and using 400 NTU solution set reading to 400.)Pour the well mixed sample into the cell and read the turbidity directly from the display. If the turbidity of the sample exceeds 40 NTU, dilute the sample properly and find the turbidity again. Then, actual turbidity =Observed turbidity x Dilution Factor.

Chlorides

Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), magnesium (MgCl2) and calcium (CaCl2). • Chloride in reasonable concentrations is not harmful to humans. At concentrations above 250 mg/L it gives detectable taste in water, which is objectionable to many people. Chloride toxicity has not been generally observed in humans. The test is done as per (IS 3025 Part 32).Take 20 ml of sample (V ml) and dilute to 100ml.If the sample is highly coloured,add 1 to 3ml of aluminium hydroxide and shake well, allow to settle, filter, wash and collect filtrate. Bring the sample pH to 7-8 by adding acid or alkali. Add 1ml Potassium chromate indicator. Titrate the solution against standard silver nitrate solution until a reddish brown precipitate is obtained. Note down the volume of titrant (V1 ml). 7.

Take 100 ml distilled water in another flask and repeat the procedure from step 3 -5 and note down the volume of AgNO3consumed as V2 ml for "blank.

Chloride concentration mg/l = (V1 – V2) x N x 35.45 x 1000 x DF/V

V= volume of the sample taken, ml

V1 = volume of AgNO3 consumed for sample, ml

N = normality of AgNO3 solution (0.0141N)

V2 = volume of AgNO3 consumed for blank, ml

35.45 is the equivalent weight of chlorine

Df = Dilution Factor

Hardness

Hardness of water is caused by multivalent metallic captions, which react with soap to form precipitates and with certain anions present in water to form scale. The primary cations causing hardness are calcium, magnesium, strontium, ferrous ion, and manganese ions. The determination of hardness is helpful in deciding the suitability of water for domestic and industrial purpose. The design of softening process depends upon the relative amounts of carbonate and non-carbonate hardness present in water. The test is conducted as per (IS 3025 Part 21, 40). Take a sample volume of 20ml (V ml).Dilute 20ml of the sample in Erlenmeyer flask to 40ml by adding 20ml distilled water. Add 1ml of ammonia buffer to bring the pH to 10+ 0.1.Add 1 or 2 drops of the Erichrome black T indicator solution. If there is Ca or Mg hardness the solution turns wine red. Add EDTA titrant to the sample with the vigorous shaking till the wine red colour just turns blue. Note the volume of titrant added (V1ml).

Calcium Hardness, mg/1 as CaCO3 = (V2*N*50*1000)/V * DF

V= volume of the sample taken, ml

V2 = volume of titrant used for sample, ml.

N = normality of EDTA

Equivalent weight of CaCO3 = 50 g

Sulphates

Sulphate is widely distributed in nature and may be present in natural waters in concentrations ranging from a few to several thousand milligrams / litre. Sulphate salts are mostly soluble in water and impart hardness. Sulphates are of considerable concern because they are indirectly responsible for two serious problems often associated with the handling and treatment of waste waters – odour and sewer corrosion problems. The test is done as per IS 3025 part 24.Standardize the turbid meter with standard barium sulphate solutions. The standards are prepared at 5 mg/l increments in the 0-40 mg/l sulphate range (at least 4 standards) and their turbidity or absorbance is read. Plot graph of standards (sulphate concentration) mg/l vs. turbidity. This will be the calibration curve. Filter the sample through 0.45 micrometre filter if there is any turbidity .Measure 20 ml of the water sample or suitable amount diluted to 20 ml in an Erlenmeyer flask. Add 1 ml hydrochloric acid solution prepared as specified and 1 ml conditioning reagent and mix well for 30 seconds. Read the absorbance on spectrophotometer after 10 minutes if glycerol conditioning reagent is used or 30 minutes if gelatin is used at 420 nm, or read the turbidity occurred on turbidity meter. Read the sulphate concentration of sample directly from the calibration curve.

Alkalinity

Collect 50 mL water sample, add 3 drops of phenolphthalein indicator, titrate the 50 mL sample with 0.02N sulphuric acid to pH 8.3 and estimate phenolphthalein alkalinity (Eq. 2a) (phenolphthalein indicator will change colour, from pink to clear, at pH 8.3). Phenolphthalein Alkalinity (in mg/L as CaCO3) = (A1×N ×50,000) / V

Test For Mpn Content

Most Probable Number (MPN) is a method used to estimate the concentration of viable microorganisms in a sample of water by means of replicate liquid broth growth in ten-fold dilutions. MPN is most commonly applied for bacteriological quality testing of water i.e. to ensure whether the water is safe or not in terms of bacteria present in it. A group of bacteria commonly referred as faecal coliforms (Ex. Escherichia Coli) act as an indicator for fecal contamination of water. MPN test for counting coliform in water is performed in 3 steps:

1. Presumptive test
2. Confirmatory test
3. Completed test

Presumptive test for untreated water

Take 5 tubes of double strength and 10 tubes of single strength for each water sample to be tested. Using a sterile pipette add 10 ml of water to 5 tubes containing 10 ml double strength medium .Similarly add 1 ml of water to 5 tubes containing 10 ml double strength medium and 0.1 ml water to remaining 5 tubes containing 10 ml double strength medium. Incubate all the tubes at 37°C for 24 hrs. If no tubes appear positive re-incubate up to 48 hrs. Compare the number of tubes giving positive reaction to a standard chart and record the number of bacteria present in it.

Confirmed test

From each of the fermentation tubes with positive results transfer one loopful of medium to:

(i) 3 ml lactose-broth or brilliant green lactose fermentation tube, (ii) to an agar slant. Incubate the inoculated lactose-broth fermentation tubes at 37°C and inspect gas formation after 24 ± 2 hours. If no gas production is seen, further incubate up to maximum of 48 ±3 hours to check gas production. The agar slants should be incubated at 37°C for 24± 2 hours and Gram-stained preparations made from the slants should be examined microscopically. The formation of gas in lactose broth and the demonstration of Gram negative, non-spore-forming bacilli in the corresponding agar indicates the presence of a member of the coliform group in the sample examined. The absence of gas formation in lactose broth or the failure to demonstrate Gram-negative, non-spore-forming bacilli in the corresponding agar slant constitutes a negative test (absence of coliforms in the tested sample).

Completed test

Since some of the positive results from the confirmatory test may be false, it is desirable to do completed tests. For this inoculum from each positive tube of the confirmatory test is streaked on a plate of EMB or Endo agar.

In this process, a loopful of sample from each positive BGLB tubes is streaked onto selective medium like Eosin Methylene Blue agar or Endo's medium. One plate each is incubated at 37°C and another at 44.5± 0.2°C for 24 hours. High temperature incubation (44.5 ±0.2) is for detection of thermo tolerant E.coli. Following incubation, all plates are examined for presence of typical colonies. Coliforms produce colonies with greenish metallic sheen which differentiates it from non-coliform colonies (show no sheen). Presence of typical colonies on high temperature (44.5 ±0.2) indicate presence of thermo tolerant E.coli.

IV. GEOGRAPHIC INFORMATION SYSTEM

Geographic Information System (GIS) is a computer based information system used to digitally represent and analyse the geographic features present on the Earth' surface and the events that taking place on it.

The meaning to represent digitally is to convert analog into a digital form.

Every object present on the Earth can be geo-referenced", is the fundamental key of associating any database to GIS.

A GIS is an information system designed to work with data referenced by spatial / geographical coordinates. In other words, GIS is both a database system with specific capabilities for spatially referenced data as well as a set of operations for working with the data. It may also be considered as a higher order map.

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

A Geographic Information System is a computer based system which is used to digitally reproduce and analyse the feature present on earth surface and the events that takes place on it.

V. CONCLUSION

The present paper analyses that water quality is decreasing and also varies in places due to many reasons. Highly populated or industrial area is more polluted than other. Tourist area is also polluted.by analysing through GIS we can specifically map up the polluted area.

Suggested measures to improve the river water involves pollution sources should be identified and priority list is to be prepared, Plan of actions to reduce pollution load is to be made, Reclamation of river is to be halted, Stop sand mining, Upgrade sanitation facilities, boat fuelling area and better drainage systems near the lake to keep fish quality at its best, Can continue coir retting but phase out the waste pith before it pollute water, alternative waste disposal site and waste by products can be identified and used as a manure, municipal solid waste disposal system should be used in an effective way, A comprehensive public awareness programme is to be conducted to improve the aesthetic environment near the river.

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