IDENTIFICATION OF GROUND WATER CONTAMINATION SOURCES IN CITY ENVIRONMENTAL USING REMOTE SENSING AND GIS TECHNIQUES

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Abstract - *Water is the basic element of social and economic infrastructure and is essential for healthy society and sustainable development. Due to rapid increase in density of population, fast urbanization, industrialization and agricultural, use the demand of water is increasing day by day. As a result surface water and ground water level is decreasing; pollution and increased demand have made good quality water scare and more expensive. Groundwater is the favorite alternative is facing threats due to anthropogenic activities in India, which has lead due to deterioration in ground water quality. The possibility of ground water contamination is due to the mixing up of toxic chemicals, fertilizers, waste disposed site and industrial sites. Hence monitoring of ground water quality has become indispensable. GIS not only facilitates data capture and processing but also serve as powerful computational tools that facilitate multimap integrations. In this project ground water quality analysis was carried out for in Madurai District water samples were collected all around the taluk the strategically analysed results are presented in a GIS based water quality mapping)*

*Key Words***:** Remote Sensing, GIS, Water quality, Interpolation

1. INTRODUCTION

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage and present all types of geographical data. The keyword to this technology is Geography – this means that some portion of the data is spatial.

Water is an essential resource for all life on the planet of the water resources on Earth only three percent of it is fresh and two-thirds of the freshwater is locked up inice caps and glaciers of the remaining one percent, a fifth is in remote, inaccessible areas and much seasonal rainfall in monsoonal deluges and floods cannot easily be used. As time advances, water is becoming scarcer and having access to clean, safe, drinking water is limited among countries. At present only about 0.08 percent of all the world's fresh water is exploited by mankind in ever increasing demand for sanitation, drinking, manufacturing, leisure and agriculture. Due to the small percentage of water remaining optimizing the fresh water we have left from natural resources has been a continuous difficulty in several locations worldwide.

Much effort in water resource management is directed at optimizing the use of water and in minimizing the environmental impact of water use on the natural environment. The observation of water as an integral part of the ecosystem is based on integrated water resource management, where the quantity and quality of the ecosystem help to determine the nature of the natural resources. Successful management of any resources requires accurate knowledge of the resource available, the uses to which it may be put, the competing demands for the resource, measures to and processes to evaluate the significance and worth of competing demands and mechanisms to translate policy decisions into actions on the ground. The neglect of rural areas in most developing countries in terms of basic infrastructures such as pipe-borne water and sanitation facilities, expose the villagers to a variety of health related problems such as water – borne diseases (SridhaR, M. K. C. 2000)

For water as a resource, this is particularly difficult since sources of water can cross many national boundaries and the uses of water include many that are difficult to assign financial value to and may also be difficult to manage in conventional terms. Examples include rare species or ecosystems or the very long term value of ancient groundwater reserves.

As the carrying capacity of the Earth increases greatly due to technological advances, urbanization in modern times occurs because of economic opportunity. This rapid urbanization happens worldwide but mostly in new rising economies and developing countries. Cities in Africa and Asia are growing fastest with 28 out of 39 megacities (a city or urban area with more than 10 million inhabitants) worldwide in these developing nations. The number of megacities will continue to rise reaching approximately 50 in 2025. With developing economieswater scarcity is a very common and very prevalent issue. Global freshwater resources dwindle in the eastern hemisphere either than at the poles, or with the majority of urban development millions live with insufficient fresh water. This is caused by polluted freshwater resources, overexploited groundwater resources, insufficient harvesting capacities in the surrounding rural areas, poorly constructed and maintained water supply systems, high amount of informal water use and insufficient technical and water management capacities.

In the areas surrounding urban centres, agriculture must compete with industry and municipal users for safe water supplies, while traditional water sources are becoming polluted with urban runoff. As cities offer the best opportunities for selling produce, farmers often have no alternative to using polluted water to irrigate their crops. Depending on how developed a city's wastewater treatment is, there can be significant health hazards related to the use of this water. Wastewater from cities can contain a mixture of pollutants. There is usually wastewater from kitchens and toilets along with rainwater runoff. This means that the water usually contains excessive levels of nutrients and salts, as well as a wide range of pathogens. Heavy metals may also be present, along with traces of antibiotics and endocrine disruptors, such as oestrogens. Developing world countries tend to have the lowest levels of wastewater treatment. Often, the water that farmers use for irrigating crops is contaminated with pathogens from sewage. The pathogens of most concern are bacteria, viruses and parasitic worms, which directly affect farmers' health and indirectly affect consumers if they eat the contaminated crops. Common illnesses includediarrhoea, which kills 1.1 million people annually and is the second most common cause of infant deaths..

1.1 Study Area

Madurai is one of the major cities in the Indian State of Tamil Nadu. It is the cultural capital of Tamil Nadu and the administrative headquarters of Madurai District, the third largest city in Tamil Nadu and 25th most populated city in India. Located on the banks of River Vaigai, Madurai has been a major settlement for two millennia. Madurai is located at 9.93°N 78.12°E. It has an average elevation of 101 meters. The city of Madurai lies on the flat and fertile plain of the river Vaigai, which runs in the northwest-southeast direction through the city, dividing it into two almost equal halves. The Sirumalai and Nagamalai hills lie to the north and west of Madurai. The land in and around Madurai is utilized largely for agricultural activity, which is fostered by the Periyar Dam.

Fig:1.Ground Water sampling locations

2. OBJECTIVES

> To Collect the ground water
> To find the water quality parameter
> To analysis water quality distribution by interpolation technique

Testing of ground Water Sample

These resources are under threat from pollution either from human life style manifested by the low level of hygiene practiced in the developing nations (Punmia B.C 1998 and Akujieze C. N.et al 2003).

The following were the test conducted in the water sample to find the properties of water sample

1.   pH
2.   Hardness

3.   Chlorine
4.   Turbidity
5.   Total dissolved solids
6.   Sulphate Test
7.   Calcium
8.   Sodium.

Interpolation Technique

GIS is all about spatial data and the tools for managing, compiling, and analyzing that data. ArcGIS Spatial Analyst extension provides a Methods of Surface Representation toolset for analyzing and modeling spatial data. A set of sample points representing changes in landscape, population, or environment can be used to visualize the continuity and variability of observed data across a surface through the use of interpolation tools. These changes can be ex-trapolated across geographic space. The morphology and characteristics of these changes can be described. The ability to create surfaces from sample data makes interpolation both powerful and useful (ESRI Education Services).

IDW method

The IDW function should be used when the set of points is dense enough to capture the extent of local surface variation needed for analysis. IDW determines cell values using a linear-weighted combination set of sample points. The weight assigned is a function of the distance of an input point from the output cell location. The greater the distance, the less influence the cell has on the output value
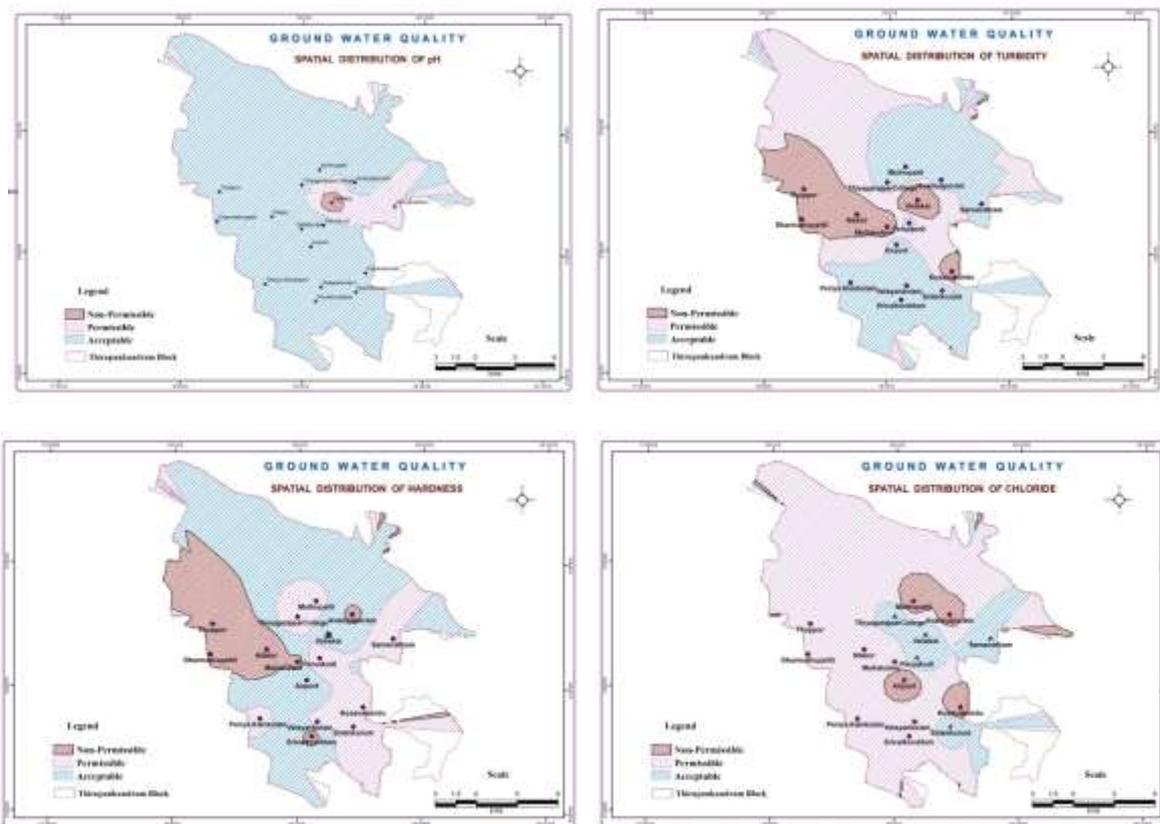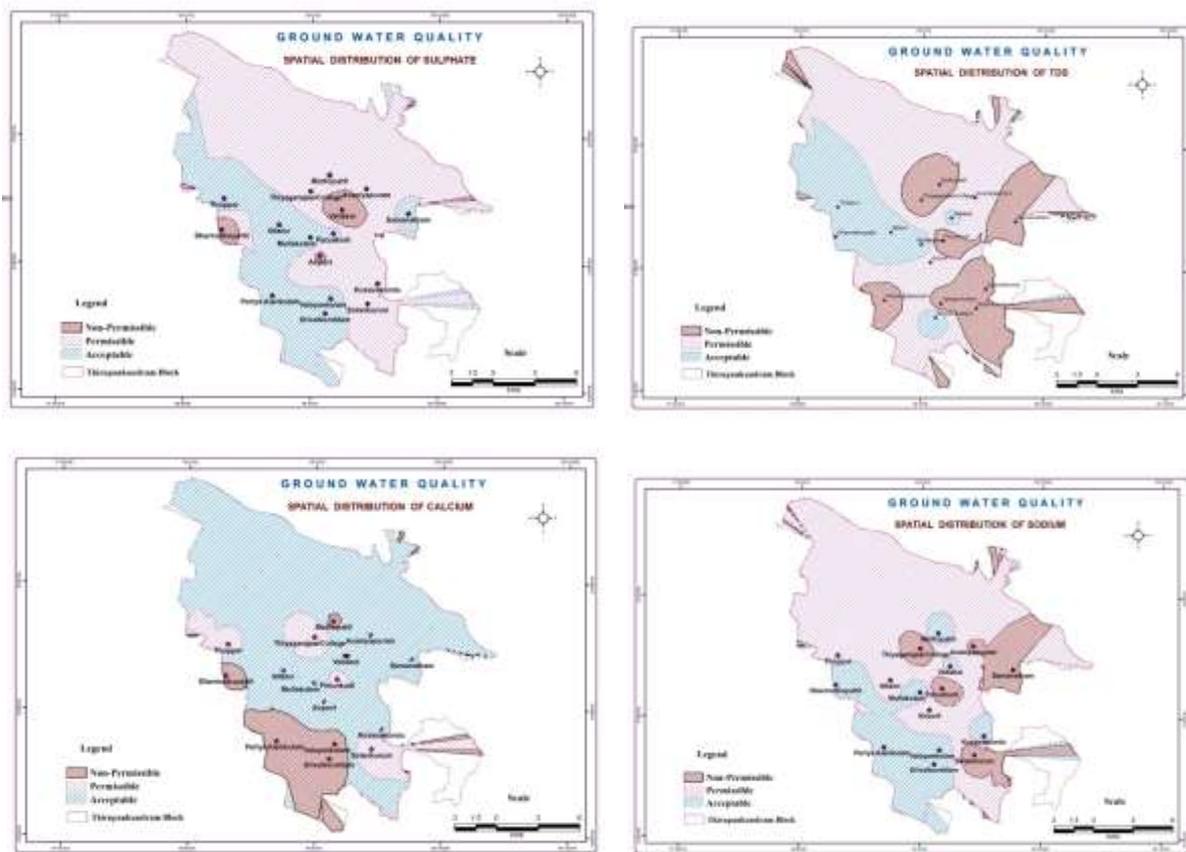
Fig:2. Ground Water Interpolated maps

pH

pH is a numeric scale used to specify acidity or basicity of an aqueous it is approximately negative of the base 10 logarithm of the molar concentration measured in unit of moles per litre of hydrogen ion most precisely it's the negative of the base 10 logarithm of the activity of the hydrogen ion solutions with the pH less than 7 are acidic and solution with pH greater than 7 are basic pure water is neutral at ph 7 (25° c) being neither primary pH standard values are determined using a concentration cell with transparent by measuring the potential different between the hydrogen electrode and a standard electrode such as silver chloride electrode the pH of aqueous solutions can be measured with a glass electrode and pH meter. pH is dimension less quantity.

TURBIDITY

Denomination	pH range
Ultra acidic	< 3.5
Extremely acidic	3.5–4.4
Very strongly acidic	4.5–5.0
Strongly acidic	5.1–5.5
Moderately acidic	5.6–6.0
Slightly acidic	6.1–6.5
Neutral	6.6–7.3
Slightly alkaline	7.4–7.8
Moderately alkaline	7.9–8.4
Strongly alkaline	8.5–9.0
Very strongly alkaline	> 9.0

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.

Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand (the settable solids), very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid.

Turbidity (or haze) is also applied to transparent solids such as glass or plastic. In plastic production, haze is defined as the percentage of light that is deflected more than 2.5° from the incoming light direction

Turbidity is commonly treated using either a settling or filtration process. Depending on the application, chemical reagents will be dosed into the wastewater stream to increase the effectiveness of the settling or filtration process. Potable water treatment and municipal wastewater plants often remove turbidity with a combination of sand filtration, settling tanks and clarifiers.

The propensity of particles to scatter a light beam focused on them is now considered a more meaningful measure of turbidity in water. Turbidity measured this way uses an instrument called a Nephelometer with the detector set up to the side of the light beam. More light reaches the detector if there are lots of small particles scattering the source beam than if there are few. The units of turbidity from a calibrated Nephelometer are called Nephelometric Turbidity Units (NTU).

HARDNESS

Classification	Hardness in mg/L
Soft	0–60
Moderately hard	61–120
Hard	121–180
Very hard	= 181

Hard water is water that has high mineral content (in contrast with "soft water"). Hard water is formed when water percolates through deposits of limestone and chalk which are largely made up of calcium and magnesium carbonates.

Hard drinking water may have moderate health benefits, but can pose serious problems in industrial settings, where water hardness is monitored to avoid costly breakdowns in boilers, cooling towers, and other equipment that handles water. In domestic settings, hard water is often indicated by a lack of foam formation when soap is agitated in water, and by the formation of limescale in kettles and water heaters. Wherever water hardness is a concern, water softening is commonly used to reduce hard water's adverse effects.

Water's hardness is determined by the concentration of multivalent cations in the water. Multivalent cations are positively charged metal complexes with a charge greater than 1+. Usually, the cations have the charge of 2+. Common cations found in hard water include Ca2+ and Mg2+. These ions enter a water supply by leaching from minerals within an aquifer. Common calcium-containing minerals are calcite and gypsum. A common magnesium mineral is dolomite (which also contains calcium). Rainwater and distilled water are soft, because they contain few ions.

Total hardness in mg/L as $CaCO_3$ = N_2 * Eq.Wt.of.$CaCO_3$ (50) * 1000

Chlorides are widely distributed as salts of calcium, sodium and potassium in water and wastewater. In potable water, the salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water. The major taste producing salts in water are sodium chloride and calcium chloride. The salty taste is due to chloride anions and associated cations in water. In some water which is having only 250 mg /L of chloride may have a detectable salty taste if the cat-ion present in the water is sodium. On the other hand, a typical salty taste may be absent even if the water is having very high chloride concentration for example 1000 mg /L.

This is because the predominant cation present in the water is not sodium but either calcium or magnesium may be present.

The amount of chloride present in water can be easily determined by titrating the given water sample with silver nitrate solution. The silver nitrate reacts with chloride ion according to1 mole of AgNO3 reacts with 1 mole of chloride. The titrant concentration is generally 0.02 M.

Silver chloride is precipitated quantitatively, before red silver chromate is formed. The end of titration is indicated by formation of red silver chromate from excess silver nitrate. The results are expressed in mg/L of chloride (Cl- with a molecular weight of 35.453 g/mol).

Testing of Water Sample

1. Before starting the titration rinse the burette with silver nitrate solution. Fill the burette with silver nitrate solution of 0.0282 N. Adjust to zero and fix the burette in stand.

2. Take 20 mL of the sample in a clean 250mL conical flask

3. Add 1 mL of Potassium Chromate indicator to get light yellow color 4.Titrate the sample against silver nitrate solution until the color changes from   yellow to brick red. i.e., the end point.

5. Note the volume of Silver nitrate added (A).

6. The value of titration is 3.3 mL.

7. Repeat the procedure for concordant values.

   Amount of chloride in mg/l   = N_4 * Eq.Wt.of.Chloride (35.5) * 1000

SULPHATE

Sulphates is widely distributed in nature and may be present in natural waters in concentration ranging from few hundred to several thousand mg/L. Sulphates occur naturally in numerous minerals, including barite, epsomite and gypsum. These dissolved minerals contribute to the mineral content of drinking-waters.

Acid Mine Drainage (AMD) may contribute large amounts of sulphates through pyrite oxidation. Sulfate is the second most abundant anion in seawater. Its high concentration owes to the high to moderate solubility of the salts that it forms with the major cations in seawater, namely, Na, Mg^{2+}, and Ca^{2+}.

Sulphates are of considerable concern because they are indirectly responsible for two serious problems often associated with the handling and treatment of wastewater. They are odour and sewer corrosion problem result from the reduction of sulphatesto hydrogen sulphide under anaerobicconditions.

The amount of sulphates in wastewater is a factor of concern in determining the magnitude of problems that can arise from reduction of sulphates to hydrogen sulphide. For example knowledge of the sulphates content of the sludge or waste fed to digestion units provides a means of estimating the hydrogen sulphide content of the gas produced. From this information, the design engineer can determine whether scrubbing facilities will be needed to remove hydrogen sulphide and size of the units required.

There is an increasing likelihood of complaints arising from a noticeable taste as concentrations in water increase above 500 mg/litre.

The amount of sulphate present in sample as so_4 =   mg of sulphate* 1000 /Volume of sample

T0TAL DISSOLVED SOLIDS

Total dissolved solids (TDS) is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. Generally the operational definition is that the solids must be small enough to survive filtration through a filter with two-micrometer (nominal size, or smaller) pores. Total dissolved solids are normally discussed only for freshwater systems, as salinity includes some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants.

Primary sources for TDS in receiving waters are agricultural and residential runoff, clay rich mountain waters, leaching of soil contamination and point source water pollutiondischarge from industrial or sewage treatment plants. The most common chemical constituents are calcium, phosphates, nitrates, sodium, potassium and chloride, which are found in nutrient runoff, general stormwater runoff and runoff from snowy climates where road de-icing salts are applied. The chemicals may be cations, anions, molecules or agglomerations on the order of one thousand or fewer molecules, so long as a soluble micro-granule is formed. More exotic and harmful elements of TDS are pesticides arising from surface runoff. Certain naturally occurring total dissolved solids arise from the weathering and dissolution of rocks and soils. The United States has established a secondary water quality standard of 500 mg/l to provide for palatability of drinking water.

Total dissolved solids are differentiated from total suspended solids (**TSS**), in that the latter cannot pass through a sieve of two micrometers and yet are indefinitely suspended in solution. The term "settleable solids" refers to material of any size that will not remain suspended or dissolved in a holding tank not subject to motion, and excludes both TDS and TSS.[1] Settleable solids may include larger particulate matter or insoluble molecules.

CALCIUM TEST

Calcium is the most abundant and one of the most important minerals in the body. It is essential for cell signaling and the proper functioning of muscles, nerves, and the heart. Calcium is needed for blood clotting and is crucial for the formation, density, and maintenance of bones and teeth. This test measures the amount of calcium in the blood or urine, which reflects the amount of total and ionized calcium in the body.

IV. RESULTS AND DISCUSSION

Table: Ground water quality of parameters

S. no	NAME	pH	TDS	Sulphate	Turbidity	Hardness	Chlorides	Sodium	ca
1	Thiyagarajaar College	7.3	154	45.38	1	100	148	104.1	88.18
2	Avaniyapuram	7.4	1297	41.54	1	588	396	224.2	67.33
3	Perunkudi	7.6	113	37.23	1	116	114	110.5	76.95
4	Samanatham	7.2	111	37.44	1	88	88	124.6	65.73
5	Airport	7.5	1253	46.99	1	428	464	234.2	73.74
6	Muthupatti	7.4	682	39.00	0	340	440	390.1	62.52
7	Kusavakundu	7.6	668	39.18	2	352	452	392.3	68.93
8	Valayankulam	7.7	497	38.76	0	320	298	350.2	60.92
9	PeriyaAlankulam	7.6	521	38.34	1	328	306	372.5	49.69
10	Solankuruni	7.3	154	45.38	1	100	148	104.1	88.18
11	Dharmathupattii	7.5	2310	52.00	2	688	296	404.0	57.72
12	Thoppur	7.5	2370	34.35	2	836	318	287.3	76.95
13	Nilaiur	7.5	2340	28.25	2	788	304	295.4	72.14
14	Mullakulam	7.6	2370	32.10	2	592	286	387.2	67.33
15	Srivaikunddam	7.7	2380	33.52	1	608	282	395.4	52.90
16	Vallakal	6.3	1870	61.20	3	552	148	340.9	64.13

Table:2. Area distributions of ground water quality

	pH	TDS	Sulphate	Turbidity	Hardness	Cl	sodium	Ca
Non-permissible	1.98	5.66	9.83	47.2	53.45	22.69	39.19	29.8
Permissible	26.67	150.86	188.66	110.49	160.42	40.18	182.8	215.17
Acceptable	256.66	59.05	87.08	127.2	71.67	222.69	63.53	40.7

According to BIS standard

- ✓ Due to seasonal variation the ground water level got decreased.
- ✓ Due to decrement in the ground water level, there was variation in the following water quality parameter. pH level got increased
- ✓ Turbidity level has no change
- ✓ Hardness level has no change
- ✓ Chloride level got increased
- ✓ Sulphate level has no change
- ✓ Total Dissolved Solids has increased
- ✓ Calcium level has no change
- ✓ Sodium level has no change

- ➢ Since the variation in the parameters got decreased due to the change in the ground water level more number of trees can be planted so that the ground water level can be improved.

- ➢ Planting of trees imparts rain. And this rain can be collected by using rain water harvesting.

- ➢ We conclude that as per BIS standard the following areas are having good quality of ground water in the study area.

3. CONCLUSION

Water quality analysis may lead to water resource management is the activity of planning, developing, distributing and managing the optimum use of water resources. It is a sub-set of water cycle management. Ideally, water resource management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demands. As with other resource management, this is rarely possible in practice. It is recommended that increased and continued combined environmental interventions, through public health education by community based health workers, awareness and sensitization campaigns be carried out for improved household and community sanitation in study area. Wells located within 25 meters from pollution source should be abandoned and future wells should be constructed beyond 250 meters from pollution source. Adequate solid waste disposal method should be adopted, phasing out open dumpsites to safeguard public health from water borne diseases.

REFERENCES

[1] SridhaR, M. K. C.: Ground water in Nigerian urban centers: problems and options. Schriftenr Ver Wasser Boden Luftyg., 2000, 105, 393-397

[2] Punmia B. C.; Jain A. K.: Wastewater Engineering. Laxmi Publications (P) Ltd, New Delhi, 1998.

[3] Akujieze C. N.; Coker, S. J.; Oteze, G. E.:Groundwater in Nigeria – a millennium experience – distribution, practice, problems and solutions. Hydrogeology Journal, 2003, 1, 259 -274.