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Groundwater quality - Assessment on Anekal Taluk, Bangalore Urban district, India

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Abstract: *Water as a resource, basic amenity and universal solvent is shared by population. The physicochemical and biological quality study of Anekal Taluk has been taken up to evaluate its suitability for potable purposes. 1026 water samples were collected from bore well, hand pumps of 272 villages covering in Anekal Taluk. The quality of groundwater has been made through the analysis of pH, colour, electrical conductivity, turbidity, total dissolved solids, alkalinity, chlorides, total hardness, calcium, fluoride, nitrate, sulphate, iron and E.coli. The quality of groundwater assessed in the study area is discussed in detail.*

Key words: *Groundwater quality, Groundwater pollution, Assessment, Anekal Taluk.*

Introduction

Water being a universal solvent has been and is being utilized by man kind time and now. Of the total amount of global water, only 2.4% is distributed on the main land, of which only a small portion can be utilized as fresh water. The available fresh water to man is hardly 0.3-0.5% of the total water available on the earth and therefore, its judicious use is imperative (Ganesh and Kale, 1995). The fresh water is a finite and limited resource (Bouwer, 2000). The utilization of water from ages has led to its over exploitation coupled with the growing population along with improved standard of living as a consequence of technological innovations (Todd, 1995, and Indra Raj, 2000). This contamination of groundwater is not away from the evils of modernization. Therefore, quality of groundwater is deteriorating at a faster pace due to pollution ranging from septic tanks (Olaniya and Saxena, 1977; Gillison and Patmont, 1983), land fill leachates, domestic sewage (Eison and Anderson, 1980; Sharma and Kaur, 1995; Subba Rao, 1995), agricultural runoff/ agricultural fields (Banerji, 1983; Handa; 1986, Ramachandra *et al.,* 1991; Datta and Sen Gupta, 1996, Somashekar *et al.,* 2000) and industrial wastes (Sharma and Kaur, 1995; Todd, 1995 and Rengaraj *et al.,* 1996; Indra Raj, 2000). Contamination of groundwater also depends on the geology of the area and it is rapid in hard rock areas especially in lime stone regions where extensive cavern systems are below the water table (Singh, 1982). This is a feature common, not only in developed countries but also in developing countries like India. The changes in quality of groundwater response to variation in physical, chemical and biological environments through which it passes (Singh *et al.,* 2003).

Groundwater resource in Anekal Taluk is widely exploited for irrigation and other domestic purposes in addition to drinking purpose. The taluk resident mainly depends on groundwater for their drinking water. Concentration of pollutants more than their permissible limits in drinking water leads to health problems, such as water borne diseases, like fluorosis, typhoid, jaundice, cholera, premature baby and other problems, especially in infants (Spalding and Exner, 1993). Anekal Taluk is located in the southeast corner of Karnataka state spans to a geographical area of 2,191 km^2. Anekal Taluk occupies an area about 535 km^2 as shown in Fig 1. The topography of the region is uneven landscape with intermingling of hills and valleys and bare rocky outcrops raises to about 60 to 90 feet above ground level. The ground is dissected and is a region of rapid erosion. The eastern portion of taluk forms a plain country and western portion is wild and marked by a continuous chain of hills through which several rivulets combine together and drain into river Arkavathi. Geologically, gneissic granites and dyke rocks are found belonging to precambrian age. Groundwater in the district occurs under water table conditions in the weathered mantle of granitic gneisses and joints, cracks and crevices of the basement rock. It is estimated that surface run off and evapo-transpiration account for nearly 80 percent allowing only 20 percent of rainfall adding to groundwater reservoir.

In order to assess the ground water quality of the study area, the following objectives are envisaged.

1. To assess the groundwater quality of the study area.
2. To develop precautionary measures to prevent ground water contamination.

Materials and Methods

Sample collection: Grab sampling has been adopted to collect groundwater samples. The samples were collected in polythene containers of 2 liters capacity for physicochemical analysis after pumping out sufficient quantity of water from the source such that, the sample collected served as a representative sample. For *E. coli* analysis, samples were collected in sterilized glass bottles of 1 liter capacity from the source. The samples thus collected were transported to the laboratory at freezer condition (4°C).

Analysis of groundwater samples: The groundwater quality was assessed by the analysis of physicochemical and bacteriological parameters such as pH, colour, turbidity, electrical conductivity, total dissolved solids, alkalinity, chlorides, total hardness, calcium hardness, nitrates, sulphates, iron, fluorides and *E. coli* (membrane filtration technique) using standard methods (APHA, 1995).

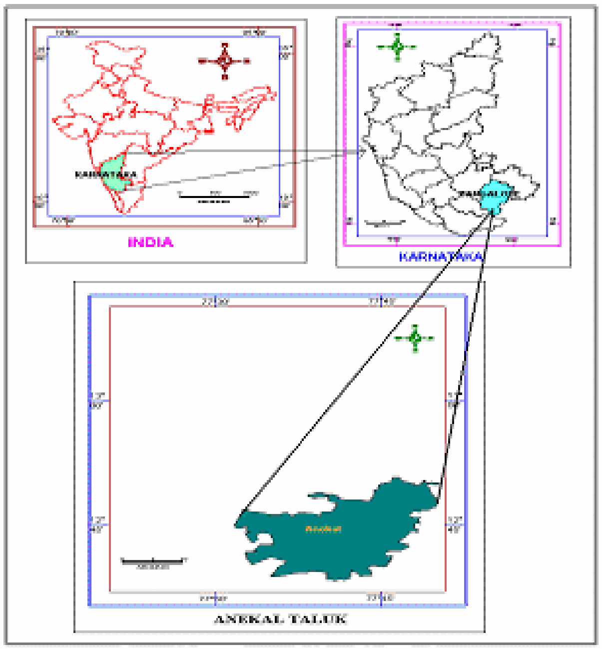

Fig 1: Location map of the study area

Results and Discussion

The physicochemical and biological results have been subjected to statistical analysis and given in the Table 1. The observed ranges of the samples were compared with Bureau of Indian Standards (BIS- 10500: 1991). The samples collected showed considerable variations in the quality of groundwater. This might be due to irregular distribution of rocks or due to variation in the depth of sample points. A comparison of the depth of hand pump installation indicates that the deep installations are better than the shallow installations with respect to the groundwater quality, since shallow hand pumps draw water from the topmost water bearing structure, which is contaminated by various natural and anthropogenic sources percolating in the vicinity (Garg *et al.,* 2003).

Physicochemical: The pH value of the samples in the study area varied from 5.51 – 9.93 with a mean of 7.45 indicating slightly acidic to slightly alkaline nature. In the study area 9.45% of groundwater samples were found exceeding the acceptable limit of BIS. High pH value induces the formation of trihalomethanes, which are toxic, while pH below 6.5 starts corrosion in pipe thereby releasing toxic metals such as zinc, lead, cadmium and copper (Shrivastava and Patil, 2002). It was noticed that the pH value of the water appears to be dependent upon the relative quantities of calcium, carbonates and bicarbonates. The water tends to be more alkaline when it possesses carbonates (Zafar, 1966; Suryanarayana, 1995).

The colour value of the sample in the study area varied widely between 0 – 20 Hazen unit with a mean of 4.19 Hazen unit. Percentage of groundwater sample exceeding the acceptable limit of BIS were 24.07%. The presence of colouring material in the water is due to contact with organic debris, such as leaves, lignin containing materials and wood, which contributes in various stages of decomposition. Generally, tannins, humic acid and humates from the decomposition of lignin are considered as the principal colour bodies. It can also depend on vegetable extracts of considerable variety. In the present study, it can be said that the iron and its compounds contributed also to colour. Most people residing near the water source with intense colour have abandoned them as a source of drinking water.

Electrical conductivity value of the study area varied from 205 – 3084 µmhos/cm with a mean of 2071.85 µmhos/cm and 18.62% samples exceeded standards of BIS prescribed for drinking. Electrical conductivity is a measure of water's capacity to conduct electric current. As most of the salts in the water are present in the ionic form, are responsible to conduct electric current. Generally, groundwater tends to have high electrical conductivity due to the presence of high amount of dissolved salts. Electrical conductivity is a decisive parameter in determining suitability of water for particular purpose and classified according to electrical conductivity as follows,

EC in µmhos/cm at 25°C	Classification
< 250	Excellent
250 – 750	Good
750 – 2000	Permissible
2000 – 3000	Doubtful
> 3000	Unsuitable

Turbidity is an important parameter for characterizing the quality of water. Turbidity in water may be due to wide variety of suspended materials, which range in size from colloidal to coarse dispersions, depending upon the degree of turbulence. Turbidity in the study area range from 0 – 316 NTU with a mean of 8.93 NTU and 26.32% of groundwater samples were found exceeding the acceptable limits of BIS, which indicates the presence of suspended and colloidal matter such as clays, silt and fibrous particles like asbestos minerals (WHO, 1991). Leaching of organic matter, industrial, domestic wastes etc., also contribute to turbidity in groundwater samples. Bacterial growth in the casing pipes due to improper maintenance and unaesthetic surroundings also account for higher turbidity. Inorganic nutrients such as nitrogen and phosphorus present in agricultural runoff stimulate the growth of algae, which also contributes to turbidity (Sawyer *et. al.,* 2000). The turbidity in the water samples is an indication of pollution of water particularly due to the source near the drain, cesspool, ditches or manured grounds. There are chances for the pathogenic organisms to be enclosed in the turbidity causing particles thus leading to health hazards (Manivasakam, 2000).

The total dissolved solids (TDS) in the study area varied from 14 – 7770 mg/l with a mean value of 1034.07 mg/l and 9.55% of the samples were found exceeding the limit of BIS. In water samples, most of the matter is in dissolved form and consists mainly of inorganic salts, small amounts of organic matter and dissolved gases, which contribute to TDS. Based on TDS groundwater is classified as follows:

Table – 1: Statistical analysis for ground water quality.

Parameters	Observed range	Mean	Standard limits (BIS-10500: 1991) Acceptable limit	Maximum permissible limit	Standard deviation	Percentage of samples exceeding acceptable limits of standards (%)
pH	5.51–9.93	7.45	6.5 – 8.5	No relaxation	± 0.64	9.45
Colour hazen unit	0-20	4.19	5	25	± 0.11	24.07
EC μmho/cm	205 – 3084	2071.85	1500	3000	± 5.0	18.62
Turbidity NTU	0 – 316	8.93	5	10	± 0.36	26.32
Total dissolved Solids mg/l	14 – 7770	1034.07	500	2000	± 0.68	9.55
Alkalinity mg/l as $CaCO_3$	20 – 710	275.68	200	600	± 065	1.07
Chloride mg/l	9.89 –5918.2	218.15	250	1000	± 0.87	1.27
Total hardness mg/l as $CaCO_3$	20 – 4600	225.59	300	600	± 0.77	2.83
Calcium mg/l as $CaCO_3$	8 – 3400	152.74	75	200	± 1.2	19.98
Fluoride mg/l	0 – 16	0.84	1.0	1.5	± 0.2	10.04
Nitrate mg/l	0.01–6.72	2.00	45	100	± 1.45	0.00
Sulphate mg/l	0–1678.2	18.63	200	400	± 1.6	0.68
Iron mg/l	0 – 10.15	1.26	0.3	1.0	± 1.51	42.20
E.coli/100ml	0 – 364	12.93	Nil	10	-	31.19

Classification	**TDS in mg/l**
Non – saline	< 1000
Slightly saline	1000 – 3000
Moderately saline	3000 – 10000
Very saline	> 10000

The Alkalinity ranged between 20 – 710 mg/l as $CaCO_3$ with a mean value of 275.68 mg/l as, $CaCO_3$ indicated high alkaline nature of water in the area and 1.07% of samples were found exceeding the acceptable limit of BIS. The excess of alkalinity could be due to the minerals, which dissolved in water from mineral rich soil. The various ionic species that contribute mainly to alkalinity includes bicarbonates, carbonates, hydroxides, phosphates, borates, silicates and organic acids. In some cases, ammonia or hydroxides are also accountable to the alkalinity (Sawyer *et. al.,* 2000).

The chlorides varied widely from 9.89 – 5918.2 mg/l with a mean value of 218.15 mg/l and 1.27% of samples were found exceeding the acceptable limit of BIS. Naturally, chloride occurs in all types of waters. The contribution of chloride in the groundwater is due to minerals like apatite, mica, and hornblende and also from the liquid inclusions of igneous rocks (Das and Malik, 1988). Human excreta, particularly the urine, contain chloride in an amount equal to the chlorides consumed with food and water (averages to about 6 g of chlorides per person per day), increases the amount of chloride in municipal wastewater to about 15 mg/l above that of the carriage water in lotic systems (Sawyer *et. al*., 2000). In addition leachate from land fills (Eison and Anderson, 1980, Sharma and Kaur, 1995, Subba Rao and Subba Rao, 1995), septic tanks and pit latrines (Olaniya and Saxena, 1977, Craig and Anderson, 1979, Gillison and Patmont, 1983, Vates, 1986, Todd, 1995, Sharma and Kaur, 1995, Polprasert, 1996) also contributes a significant amount of chlorides to groundwater.

The total hardness ranged between 20 - 4600 mg/l as $CaCO_3$ with a mean value of 225.59 mg/l as $CaCO_3$ which indicated hard water and 2.83% of samples were found exceeding the acceptable limits of BIS. Hardness in water is caused by certain salts held in solution. The most common are the carbonates, fluorides and sulphates of calcium and magnesium. The principal hardness causing cations are calcium, magnesium, strontium, ferrous and manganese ions. The cations plus the most important anions that contributes are bicarbonates, sulphates, chlorides, nitrates and silicates. The hardness may be advantageous in certain conditions; it prevents the corrosion in the pipes by forming a thin layer of scale, and reduces the entry of heavy metals from the pipe to the water (Shrivastava *et al.,* 2002). Water can be classified in terms of degree of hardness as follows,

Total hardness in mg/l	**Degree of hardness**
0 – 75	Soft
75 – 150	Moderately hard
150 – 300	Hard
> 300	Very hard

Calcium is one of the most abundant substance found in natural water in higher quantities in the rocks. Higher level of calcium is not desirable in washing, bathing and laundering, while small concentration of calcium is beneficial in reducing the corrosion in pipes. Calcium in the study area varied widely from 8 mg/l to 3400 mg/l as $CaCO_3$ with a mean value of 152.74 mg/l as $CaCO_3$ and 19.98% of samples were found exceeding the acceptable limits of BIS. This might be due to the geology of the area. The area is basically of granitic terrain. Experts have opined that the difference in relative mobility of calcium, magnesium, sodium and potassium is more distinct in the groundwaters from granitic terrain and the higher concentrations of calcium, magnesium, chlorides and bicarbonates in several cases are probably due to their low rate of removal by soil (Somashekar *et al*., 2000).

Fluoride content in the study area varied from 0 – 16 mg/l with a mean value of 0.84 mg/l and 10.04% of the samples were found exceeding the acceptable limits of BIS standards. Fluorides samples which exceeded the acceptable limit are not recommended for consumption without treatment. Fluoride is considered as an essential element though health problems may arise from either deficiency or excess amount (Gopal *et al*, 1985). Much of the fluoride entering the human body is obtained from drinking water (Saralakumari and Rao, 1993). Fluoride concentration of 0.4 ppm in drinking water causes mild type of dental fluorosis (Dinesh, 1999; Gupta *et al*., 1993; Yadav and Lata, 2004).

Nitrate concentration in the study area ranged form 0.01 – 6.72 mg/l with a mean concentration of 2.00 mg/l which indicates that the groundwater has not been affected by nitrate. Human and animal wastes, industrial effluents, application of fertilizers and chemicals, seepage and silage through drainage system are the main sources of nitrate contamination of groundwater (Robertson *et al*., 1991 and Agrawal *et al*., 1999). The high concentration of nitrates in drinking water causes methenoglobinemia in infants, a disease characterized by blood changes.

Sulphate in the study area varied between 0 – 1678.2 mg/l with a mean value of 18.63 mg/l and it is found that 0.68% of water samples were exceeding the acceptable limits of BIS. A sulphate ion is one of the major anions occurring in natural waters. Many sulphate compounds are readily soluble in water. Most of them originate from the oxidation of sulphite ores, presence of shales and the solution of gypsum and anhydrite. In the absence of dissolved oxygen, nitrate and sulphates serve as a source of oxygen for biochemical oxidation produced by anaerobic bacteria. Under anaerobic conditions, sulphate ion is reduced to sulphide ion, which establishes equilibrium with hydrogen ion to form hydrogen sulphide. The presence of hydrogen sulphide leads to corrosion of pipes (Sawyer *et al.,* 2000).

Iron in the study area varies between 0 – 10.15 mg/l with a mean concentration of 1.26 mg/l and 42.20% of groundwater samples were found exceeding the acceptable limit of BIS. The presence of iron in groundwater is due to processes involved during rock formation. When the groundwater with higher concentration of iron is tapped, it quickly oxidizes to ferric state in the form of insoluble ferric hydroxide, a brown substance. Iron is an essential element in human (Moore 1973). Although iron has little concern as a health hazard, it is still considered as a nuisance in excessive quantities (Dart, 1974). It causes staining of clothes and utensils. It is also not suitable for processing of food, beverages, dyeing, bleaching etc. When water with higher concentration of iron is used in the preparation of tea and coffee, it interacts with tannin to give an inky appearance with metallic taste. The high concentration of iron in groundwater might be due to rusting of casing pipes, non-usage of bore wells for a long time, percolation of iron contaminants through space between bore hole and the casing pipe, disposal of scrap iron in open areas, contamination due to industrial activities etc. To prevent the pollution of groundwater from iron, the bore wells should be used periodically, annular space between the borehole and the casing should be cemented properly (Reddy, 2003).

Bacteriological: *E. coli* in the study area varied from 0 – 364 /100ml and the mean concentration is found to be 12/100ml with 31.19% of the samples exceeding the acceptable limit of BIS. Natural water is not free from microorganisms. The factors that determine the type of bacteria and the number of bacteria in water are; temperature, light, organic matter, acidity, salinity, protozoa, rainfall and storage conditions. The presence of the *Escherichia coli* is an indication of contamination of water supplies. *E.coli* indicates faecal contamination of drinking water. *E.coli* being pathogenic bacteria causes four types of clinical syndromes namely, urinary tract infection, diarrhoea or gastroenteritis, pyogenic infections and septicaemia. Hence, it becomes necessary to ensure that the drinking water is free from bacteriological contamination. This can be attributed to the unhygienic conditions around the bore well, cesspool formation, broken casing pipes which serve for the growth of microorganisms.

Groundwater is a precious natural resource. It forms an important part of the hydrologic cycle. In comparison with the surface water pollution, the groundwater contamination is difficult to control. From the analysis of 1026 groundwater samples collected from 272 villages it was found that in 836 samples are not suitable for domestic purposes as specified by "Indian Standard-Drinking Water Specification-IS 10500:1991". Of these samples 81.48% of water samples were found beyond the acceptable limit of BIS. In the above mentioned 836 samples at least one of the parameters is more than the acceptable limit of BIS. From the present study it is evident that groundwater quality is gradually getting deteriorated and it may deteriorate further with time. So public should be made aware of the water quality importance and hygienic conditions before use. Also it is necessary to implement certain remedial measures.

References

Agrawal, G.D., S.K. Lunkad and T. Malkhed: Diffuse agricultural nitrate pollution of groundwater in India. *Water Sci. Tech.*, **39(3),** 67-75 (1999).

APHA, AWWA and WPCF: Standard methods for the examination of water and waste water. 19th Ed., APHA New York, (1995).

Banerji, A.K.: Importance of evolving a management plan for groundwater development in the Calcutta region of the Bengal basin in eastern India. Proc. Intn. symp. groundwater resources and planning, Koblent, Germany, pp. 45-54 (1983).

Bouwer, H.: Integrated water management: Emerging issues and challenges, agricultural water management. pp. 45 (2000).

Bureau of Indian standards: Analyses of water and wastewater, BIS, Institution, Now Delhi (1991).

Craig, E. and M.P. Anderson: The effects of urbanization on groundwater quality – A Case Study. *Groundwater*. **17,** 456-462 (1979).

Dart, F.J.: The Hazard of Iron, Ottawa, Water and pollution control. Canada (1974).

Das, P.K. and S.D. Malik: Groundwater of Khatra region of Bankura district, West Bengal: Some chemical aspects in reference to its utilization. *J. Indian Water Res. Soc*., **8(3)**, 31-41 (1988).

Datta, N.C. and S. Sen Gupta: Effect of artificial aeration on the hydrographic regime of pesticide treated aquatic system. *Poll. Res*., **15(4),** 329-333 (1996).

Dinesh, C.: Fluoride and human health – cause for concern. *Indian J. Environ. Protect.*, **19(2)**, 81-89 (1999).

Eison, C. and M.P. Anderson: The effects of urbanization on groundwater quality in Milwankee, Wisconsin, USA In. Jackson, pp. 378-390 (1980).

Ganesh, R. Hegde and Y.S. Kale: Quality of lentic waters of Dharwad district in north Karnataka. *Indian J. Environ. Hlth*., **37(1),** 52-56 (1995).

Garg, V.K., B.P. Sharma and Rakesh K. Hooda: Groundwater contamination in an urban area. *J. IPHE.,* **2,** 22-28 (2003).

Gillison, R.J and C.R. Patmont: Lake phosphorus loading from septic systems by seasonally perched groundwater. *J. Water Pollut. Con. Fed*., **55,** 1297-1304 (1983).

Gopal, Ram and P.K. Gosh: Fluoride in drinking water – Its effects and removal. *Def. Sci. J.,* **35(1)**, 71-88 (1985).

Gupta, S.C., G.S. Rathore and C.S. Doshi: Fluorida distribution in ground waters of South-eastern Rajasthan. *Ind. J. Environ. Hlth.,* **35(2),** 97-106 (1993).

Handa, B.K.: Hydrochemical zones of India. *Proc. Seminar on groundwater development*, Roorkee, pp 439-450 (1986).

Indra Raj.: Issues and objectives in groundwater quality monitoring programme under hydrology project. *Proc. Natl. Symp. groundwater quality monitoring*, Bangalore, pp. 1-7 (2000).

Singh, Mandeep, Samanpreet Kaur and S.S. Sooch: Groundwater pollution – An overview. *J. IPHE*., **2**, 29-31 (2003).

Manivasakam, N.: Physicochemical examination of water, sewage and industrial effluents. IVth Ed., Pragati Prakashan, Meerut (2000).

Moore, C.V.: Iron In: Modern nutrition in health and disease, Philadelphia, Lea and Febiger. pp. 297 (1973).

Olaniya, M.S. and K.L. Saxena.: Groundwater pollution by open refuse dumps at Jaipur. *Environ. Hlth.*, **19**, 176-188 (1977).

Polprasert, C.: Organic waste recyling – Technology and management. IInd Ed., John Wiley and Sons, Chinchester. (1996).

Reddy, M.: Status of groundwater quality in Bangalore and Its environs. Groundwater (Minor Irrigation), Bangalore. pp 44 – 52 (2003).

Ramachandra, S., A. Narayanan and N.V. Pundarikathan: Nitrate and pesticide concentrations in groundwater of cultivated areas in north Madras. *Indian J. Environ. Hlth*., **33(4)**, 421-424 (1991).

Rengaraj, S., T. Elampooranan, L. Elango and V. Ramalingam: Groundwater quality in suburban regions of Madras city, India. *Poll. Res*., **15(4)**, 325-328 (1996).

Robertson, W.D., J.A. Cherry and E.A. Sudicky: Groundwater contamination from two small septic systems in sand aquifers. *Groundwater,* **29(1),** 82-91 (1991).

Saralakumari, D. and Rao, P.R.: Endemic fluorosis in the village Ralla, Anantapuram in Andra Pradesh. An epidemiological study. *Fluoride*, **26(3)**, 177-180 (1993).

Sawyer, Clair N., Perry L. McCarty and Gene F. Parkin: Chemistry for environmental engineering. IVth Ed., Tata McGraw-Hill. New Delhi (2000).

Sharma, H. and B.K. Kaur: Environmental chemistry. Goel Publishing House, Meerut. (1995).

Shrivastava, V.S. and P.R. Patil: Tapti river water pollution by industrial wastes: A statistical approach. *Nat. Environ. Pollut. Tech.*, **1(3)**, 279-283 (2002).

Singh, K.P.: Environmental effects of industrialization of groundwater resources: A case study of Ludhaina area, Punjab, India, *Proc, Int. Sym. on Soil, geology and landform-impact of land uses in developing countries*, Bangkok. **E6**. 1-E6.7. (1982).

Somashekar, R.K., V. Rameshaiah and A. Chethana Suvarna: Groundwater chemistry of Channapatna Taluk (Bangalore rural district) – Regression and cluster analysis. *J. Environ. Pollut.*, **7(2)**, 101-109 (2000).

Spalding, R. and M. Exner: Occurrence of nitrate in groundwater: A review. *J. Environ. Qual*., **22**, 392-402. (1993).

Subba Rao, C. and N.V. Subba Rao: Groundwater quality in a residential colony. *Indian J. Environ. Hlth.*, **37(4)**, 295-300. (1995).

Suryanarayana, K.: Effect of groundwater quality on health hazards in parts of eastern ghats. *Indian J. Environ. Protec.*, **15(7),** 497-500. (1995).

Todd, D.K.: Groundwater hydrology. John Wiley and Sons, New York (1995).

Vates, M.V.: Septic tank density and groundwater contamination, *Groundwater*, **23(5)**, 586-590 (1986).

WHO: Guidelines for drinking water. CBS Publishers and Distributors, New Delhi, **2**, 264. (1991).

Yadav, J.P. and S. Lata: Fluoride levels in drinking water sources in rural areas of block Jhajjar, district Jhajjar, Haryana, *J. Indian Water Works Association,* 131-136. (2004).

Zafar, A.R.: Limnology of Hussain Sagar lake, Hyderbad. *Phykos*., **5**, 115-126 (1966).

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