Ground Water Quality Index of Howrah, the Heritage City of West Bengal, India

Dipu Sukumaran[*], Chitralekha Sengupta, Rita Saha, Rakesh Chandra Saxena

Central Pollution Control Board, Southend Conclave, 502 Block, 1582 Rajdanga Main Road, Kolkata
*Corresponding author: dipudr@rediffmail.com

Abstract The present study mainly focused on trend of the drinking water quality of one of the heritage city of India, Howrah. The ground water from ten stations was analysed for two consecutive years. Water Quality Index (WQI) based on physicochemical parameters put the drinking water into "nearing to poor" in 2012 and "excellent" in 2013. But the high concentration of total and fecal coliform makes the water unsafe for drinking in both years. Alkalinity, Chloride, Total Dissolved Solids (TDS) and Nitrate concentrations in some stations were found above the drinking water standards.

Keywords: water quality index, ground water, faecal coliform, total coliform

Cite This Article: Dipu Sukumaran, Chitralekha Sengupta, Rita Saha, and Rakesh Chandra Saxena, "Ground Water Quality Index of Howrah, the Heritage City of West Bengal, India." *Applied Ecology and Environmental Sciences*, vol. 3, no. 1 (2015): 5-10. doi: 10.12691/aees-3-1-2.

1. Introduction

Natural waters are increasingly subject to a variety of pollution sources attributed to urbanization, industrialization, the proliferation of chemical, products and even natural sources [1]. Water is a prime natural resource, a basic human need and precious natural asset. The provision of drinking water that is not only safe is a matter of high priority. Hence, monitoring and conserving this important resource is essential [2]. Groundwater quality is slowly but surely declining everywhere. Thus, whatever the nature of the physical pollution, be it chemical [3] or bacteriological (bacteria, viruses) [4], the aquifers are affected. Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater due to its overexploitation and improper waste disposal, especially in urban areas. According to WHO organization, about 80% of all the diseases in human beings are caused by water [5].

All forms of life on earth draw their livelihood and growth from nature's most rich and free available reserve of water. But in many parts of the world humans have no access to the clean drinking. Water is polluted with germs, worms, or toxic chemicals and this can lead to many illnesses. In developing countries, about 80% of urban wastewater is used for irrigation paying to 70-80% food security and livelihood of urban and peri-urban communities. In agricultural areas, an excessive use of fertilizers has directly or indirectly affected the groundwater quality [6]. But beyond the quantitative aspect, it is also advisable to remain vigilant on the level of the water quality consumed by the populations [7].

Essentially all activities carried out on land have the potential to contaminate the groundwater, whether associated with urban, industrial or agricultural activities. Large scale, concentrated sources of pollution such as industrial discharges, landfills & subsurface injection of chemicals & hazardous wastes, are an obvious source of groundwater pollution. These concentrated sources can be easily detected & regulated but the more difficult problem is associated with diffuse sources of pollution like leaching of agrochemicals & animal wastes subsurface discharges from latrines & septic tanks & infiltration of polluted urban run-off & sewage where sewerage does not exists or defunct. Solid waste from industrial units is being dumped near the factories, and is subjected to reaction with percolating rainwater and reaches the groundwater level. The percolating water picks up a large amount of dissolved constituents and reaches the aquifer system and contaminates the groundwater. The problem of groundwater pollution in several parts of the country has become so acute that unless urgent steps for abatement are taken, groundwater resources may be damaged.In addition to overdraft and biological and chemical pollution, water logging is also a serious problem in many regions, impacting livelihood security of large sections of society [8].

Howrah district has an area of only 1360 km and it has the distinction of having no forest area. As per the last census the total population of the district was 4.8 million with a decennial growth of 13.3% and population density of 3300/sq.km [9]. The climate of this region is typically humid by virtue of its geographical location and receives over 1500 mm rainfall annually. The alluvial soils are the dominant soil type and occur in the alluvial flat in the Gangetic plain in several districts including Howrah. The district is occupied by the thick pile of unconsolidated

sediments laid down by the Ganga-Brahmaputra system. These unconsolidated sediments are made up of clay, silt, sand and gravel of Quaternary age overlying Mio-Pliocene sediments. The fresh water group of aquifers occur under confined condition [10]. The major water polluting agents of Howrah district are the non-existence of proper sewage collection and treatment system from the city and proper treatment of industrial effluents resulting from the chemical processing industries including paint industries. Deposition of air pollution on land also contributes to important source of groundwater pollution. Besides these there is also a solid waste dumping site.

The unplanned and non-scientific development of ground water resources, mostly driven by individual initiatives has led to an increasing stress on the available resources. Although industrialization is inevitable, various devastating ecological and human disasters which have continuously occurred over the last four decades, implicate industries as major contributors to environmental degradation and pollution problems of various magnitude [11]. The adverse impacts can be observed in the form of long-term decline of ground water levels, de-saturation of aquifer zones, increased energy consumption for lifting water from progressively deeper levels and quality deterioration due to saline water intrusion in coastal areas in different parts of the country. Fragmented land holdings, poor socio-economic status, poor infrastructure facilities, lack of knowledge of modern technologies are some of the reasons for the under-utilization of ground water resources in these areas , in spite of the growing need for boosting agricultural production [12]. In this context there is an urgent need to explore various befitting options for optimal utilization of these resources.

2. Materials and Methods

2.1. Study Area

The study area lies between the latitude 22°22'10" N & 22°46'55" N and longitudes 88°22'10" E and 87°50'45" E respectively.

2.2. Sample Collection and Analysis

The samples were collected during winter. Water samples from bore well were collected in glass containers. Before collecting samples, water from bore well was pumped out for about 5-10 minutes or until water temperature is stabilized. Samples were collected in different containers at each point to add necessary preservatives as per standard procedure. The samples were preserved in icebox and transported to laboratory within 3 hours from the time of collection and analyses.

The samples were analysed as per Standard methods for the examination of water and waste water, [13]. The results obtained were compared with the drinking water standards as specified by World Health Organisation (WHO) [14] and Bureau of Indian Standards (BIS) [15].

2.3. Microbiological Analyses

For microbiological analyses, 100 ml water samples were collected from sixteen study sites of the river stations.

The samples were subjected to serial dilution in nutrient water containing potassium dihydrogen phosphate and magnesium chloride and inoculated in multiple tubes as per the maximum probable number method. The tubes contained 10 ml of lauryl tryptose broth for the detection of total coliform and faecal coliform were incubated at 35 ± 0.5°C for three hour in A1 broth . For faecal coliform, the tubes were inoculated serially and were incubated for three hour at 35 ± 0.5°C for three hours and transferred to a water bath at 44.5 ± 0.2°C and incubated for an additional 21 ± 2 hour. Production of an acidic reaction or gas production in any A-1 broth culture within 24 hours or less is a positive reaction indicating the presence of faecal coliform [14].

2.4. Statistical Analysis

The data obtained on the physicochemical and microbiological parameters of the ground water were subjected to correlation analysis. The correlation was carried on statistical software SPSS version 18.

3. Results

In 2012, pH of the water ranged from 6.73 to 7.32 and TDS 626 mg/l to 3648mg/l. The conductivity of the samples were found between 1102 μS/cm to 5806 μS/cm. Alkalinity ranged between 298 mg/l to 725 mg/l. Chloride ranged from 192 mg/l to 2400 mg/l. Total hardness of the samples have a wide range in the samples (152 mg/l to 1820mg/l). Calcium ranged from 35 mg/l to 380 mg/l. Magnesium from 16 mg/l to 354 mg/l. Nitrate ranged from 0.01 mg/l to 5.4 mg/l. Sulphate from 1.0 to 266 mg/l. Fluoride from 0.12 to 0.50 mg/l. Total coliform ranged from 1 MPN/100ml to 123 MPN/100ml. Faecal coliform ranged from 1 MPN/100ml to 65 MPN/100ml.

In 2013, pH of the drinking water samples ranged from 6.70 to 7.36 and TDS 60 mg/l to 794 mg/l. Alkalinity ranged between 252 mg/l to 444 mg/l. Chloride ranged from 38 mg/l to 278 mg/l. Total hardness of the samples varied widely (160 mg/l to 524 mg/l). Calcium ranged from 46 mg/l to 133 mg/l. Magnesium from 10 mg/l to 39 mg/l. Nitrate ranged from 0.01 mg/l to 8.1 mg/l. Sulphate from 8mg/l to 193 mg/l. Fluoride from 0.06 to 0.57 mg/l. Total coliform ranged from 1 MPN/100ml to 245 MPN/100ml. Faecal coliform ranged from 1 MPN/100ml to 107 MPN/100ml.

3.1. Water Quality Index

For computing water quality index three steps are followed. In the first step, each of the nine parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes. The maximum weight of 5 has been assigned to the parameter nitrate due to its major importance in water quality assessment [16]. Magnesium which is given weight of 2 as magnesium by itself may not be that harmful [12].

Second step, relative weight (Wi) is computed from the following equation:

$$Wi = wi \div \sum_{i=1}^{n} wi$$

Where (Wi) is the relative weight, (wi) is the weight of each parameter and 'n' is the number of parameters. The Calculated Water Quality Index of drinking water of How rah is given in Table 1 and Table 2. In the third step, a quality rating scale (qi) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the BIS and the result is multiplied by 100:

$$qi = (Ci / Si) * 100$$

Where qi is the quality rating, Ci is the concentration of each chemical parameter in each water sample in mg/l, and Si is the BIS (Bureau of Indian standards) water standard for each chemical parameter in mg/l according to the guidelines of the BIS and WHO.

For computing the WQI, the SIi is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation

$$SIi = Wi * qi$$

$$WQI = \sum SIi$$

SIi is the sub index of Ith parameter, qi is the rating based on concentration of ith parameter and n is the number of parameter. The computed WQI values are classified into five types "excellent water", "good water", "poor water" "very poor water" and "water unsuitable for drinking" as shown in the Table 3.

Table 1. The Water Quality Index of, 2012

	Concentration of parameters (mg/l) (Ci)	Weightage (wi)	Relative weight (Wi)	Standard Concentration (mg/l) (Si)	Quality Rating (qi)	Sub Index (SIi)
TDS	1472	4	0.09	500	294	26.8
Cl⁻	520	3	0.07	250	208	14.2
Alk	469	3	0.07	200	234	16.0
Total Hard	640	3	0.07	300	213	14.5
Ca	126	2	0.05	75	168	7.6
Mg	80	2	0.05	30	266	12.1
NO$_3$-N	1	5	0.11	45	3	0.3
Sulphate	57	4	0.09	200	28	2.6
Fluoride	0.7	4	0.09	1	31	2.8
					WQI= 96.9	

Table 2. The Water Quality Index, 2013

	Concentration of parameters (mg/l) (Ci)	Weightage (wi)	Relative weight (Wi)	Standard Concentration (mg/l) (Si)	Quality Rating (qi)	Sub Index (SIi)
TDS	343.7	4	0.09	500	69	6.2
Cl⁻	191.2	3	0.07	250	76	5.2
Alk	319.6	3	0.07	200	160	10.9
Total Hard	288.8	3	0.07	300	96	6.6
Ca	79.42	2	0.05	75	106	4.8
Mg	21.9	2	0.05	30	73	3.3
NO$_3$-N	3.54	5	0.11	45	8	0.9
Sulphate	33.38	4	0.09	200	17	1.5
Fluoride	0.348	4	0.09	1	35	3.2
					WQI= 42.6	

Table 3. Water quality classification based on WQI value [17]

WQI Value	Water Quality
<50	Excellent
50 – 100	Good water
100 – 200	Poor water
200 – 300	Very poor water
>300	Water unsuitable for drinking

4. Discussion

For satisfactory water disinfection and clarification at all stages the control of pH is very necessary. Effective disinfection with chlorine, the pH should preferably be less than 8. pH of all the stations in Howrah were found within the range of Indian Standards (6.5-8.5). The Total dissolved solids (TDS) of all stations were higher than the standard in 2012 and only one station in 2013. Craun et al. [18] reported that increase TDS concentrations in drinking water cause of cancer, coronary heart disease, arteriosclerotic heart disease and cardiovascular disease.
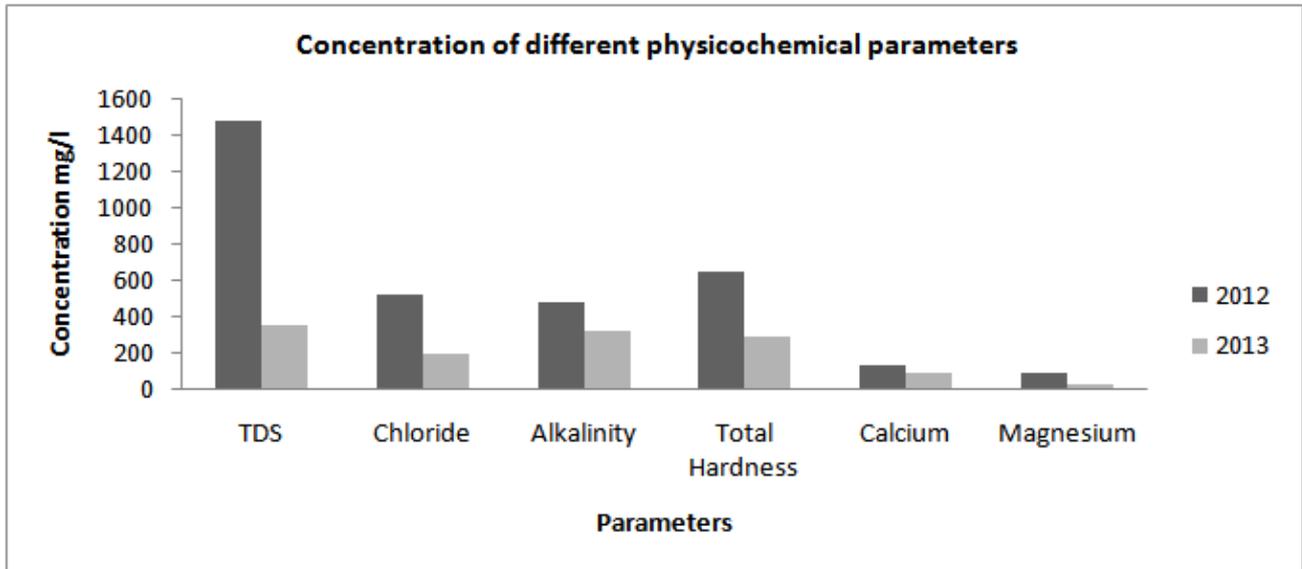
Figure 1. Concentration of physicochemical parameters in 2012 and 2013

The Total Hardness is an important parameter of water quality whether it is to be used for domestic, industrial or agricultural purposes. Total hardness of the five stations of was above the Indian Standards (BIS: 2012) in 2012 and three stations in 2013 for drinking water (Figure 1). Total hardness has a high significant correlation (p<0.01) between calcium and magnesium concentration and TDS. The calcium concentrations in five stations were found above the standards in both sampling period.

The nitrate concentrations in all the water samples were well within the limit of standards in both sampling period. Nitrate losses from non point agricultural sources, mainly originated by fertilizers application, have been recognized as one of the most serious threats for pollution of groundwater [16]. An improvement of knowledge is however essential to make the water services more powerful and to reinforce the policy for the access to safe water in the country [7]. Nitrates and nitrites may themselves be carcinogens or may be converted in the body to a class of compounds known as the nitrosamines, compounds that are known to be carcinogens [17].

Chloride concentration of six stations in 2012 and two stations were found above the standards for drinking water. Chloride has a high significant correlation (p<0.01) between TDS, conductivity and Total hardness. The high chloride concentration may be due to the salt water intrusion. The whole area lies in the tidal zone area of Indian Ocean. A report showed that people drinking chlorinated water over long periods have a 21% increase in the risk of contracting bladder cancer and a 38% increase in the risk of rectal cancer [19]. Low fluoride concentrations in both the rounds is a matter of concern particularly when the lower limit stipulated by BIS (2012) was 0.6 mg/l. The factors which control the fluoride concentration includes the climate of the area and the presence of accessory minerals in the rock mineral assemblage through which the ground water is circulating [20]. In the present study the concentration of fluoride is within the permissible limits of WHO.
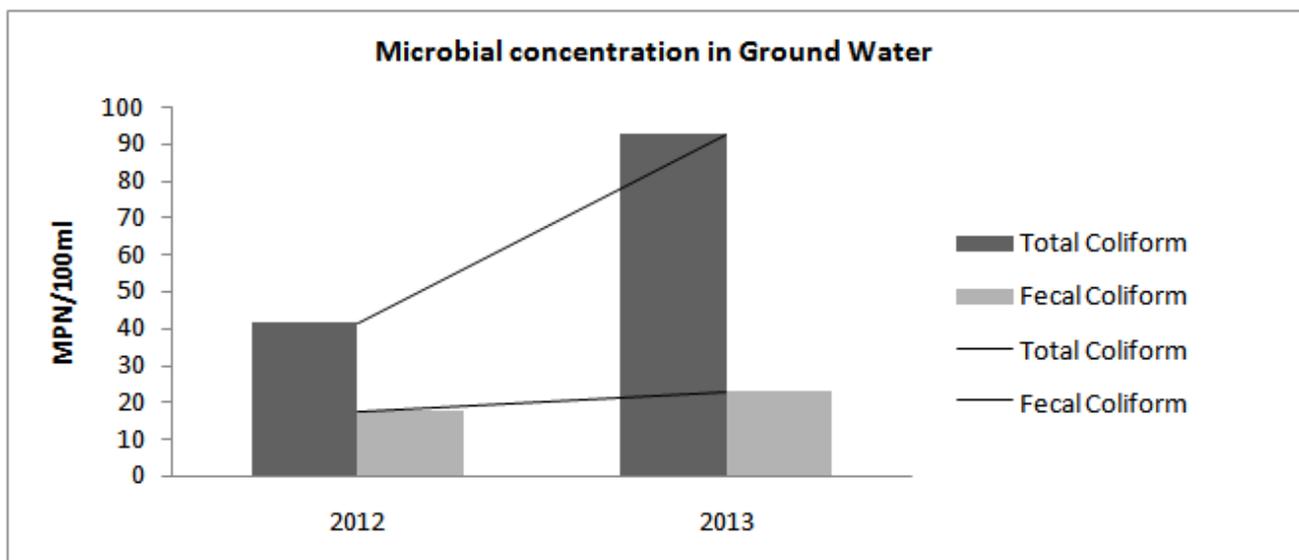

Figure 2. Total and fecal coliform concentration in ground water

The concentration of microbial concentration was found increased in 2013 than 2012 (Figure 2). Most waterborne pathogens are introduced into drinking-water supplies in human or animal faeces, do not grow in water and initiate infection in the gastrointestinal tract following ingestion [12]. In all the stations in both years, the total and faecal coliform exceeds the standards for drinking water [11,12] which put the groundwater unfit for drinking. But lack of other drinking water sources people is forced to drink the water. The hospital records of Howrah states that number of patients suffering from typhoid, gastroenteritis and hepatitis has gone up drastically in these years. This is a matter of serious concern in the state of West Bengal particularly for Howrah district. The untreated sewage and sewerage flowing in various open drains are one of the causes of ground water quality deterioration [21].

Water quality index provides a single number that express overall water quality at a certain location and time, based on several water quality parameters. Water Quality Index (WQI) is one of the most effective tools to provide feedback on the quality of water to the policy makers and environmentalists. It provides a single number expressing overall water quality status of a certain time and location [22]. The objective of water quality index is to turn complex water quality data into information that is useful for public. However a water quality index based on some very important parameters can provide a simple indicator of water quality [23]. The WQI of Howrah in 2012 is 96.9 and in 2013 is 42.6. This shows the trend in water quality. In 2012 the drinking water of Howrah is nearing the "poor water" category but recouped to "excellent water" in terms of physicochemical parameters as per the water quality classification based on WQI value. But in both years total and fecal coliform count in water is very high. Interestingly it is high in 2013 than 2012. The single parameter which has high significance in determining the quality of drinking water has to be thoroughly studied and to be checked.

5. Conclusion

The groundwater quality problems are mainly due to contamination by geogenic and man-made sources and sea water intrusion due to over-abstraction of groundwater in Howrah.Over abstraction of this limited resource, in addition to erratic waste disposal in surface waters, enhances the contamination of groundwater. With fast urban growth and increasing standard of living the waste generation has steeply increased in India, especially in large urban centres. Due to paucity of resources, the local authorities, who are responsible for waste management are not able to adequately address the problem. The qualities of groundwater with respect to bacteriological parameters are alarming. This can be attributed to in-adequate collection of sewage, garbage leading to accumulation of wastewater and garbage, inadequate maintenance of hand pumps, improper sanitation and unhygienic conditions around the structures.

Acknowledgments

References

[1] Ramesh, R., Purvaja, G. R., Raveendra, V.I. 1995. The problem of groundwater pollution: a case study from Madras city, India *Man's Influence on Freshwater Ecosystems and Water Use* (Proceedings of a Boulder Symposium). IAHS Publ. no. 230. 147.

[2] Suvarna, T., Mohammad, J. S. and Rushikesh, S., 2012. "Spatial Distribution of Ground Water Quality In Some Selected Parts of Pune City, Maharashtra, India Using GIS". *Current World Environment*, 7(2), 281-286.

[3] Attoui, B., Kherci, N. and Bousnoubra, H., 2012. "State of vulnerability to pollution of the big reservoirs of groundwater in the region of Annaba-Bouteldja (NE Algeria)". *Geographia Technica*. 2:1-13.

[4] Schijven, J.F., Hassnizadeh S.M. and Husman, A.M., 2010. "Vulnerability of unconfined aquifers to virus contamination". *Water Res.*, 44(4):1170-1181.

[5] Shivasharanappa, Padaki S. and Mallikarjun S. H., 2011. "Assessment of ground water quality characteristics and Water Quality Index (WQI) of Bidar city and its industrial area, Karnataka State, India". *International Journal of Environmental Sciences*, 2(2), 965-976.

[6] Huang, T., Pang, Z. and Edmunds, W.M., 2012. "Soil profile evolution following land-use change: Implications for groundwater quantity and quality". *Hydrol. Process* 27(8), 1238-1252.

[7] Diodato, N., Esposito, L., Bellocchi, G., Vernacchia, L., Fiorillo, F. and Guadagno, F.M., 2013. "Assessment of the Spatial Uncertainty of Nitrates in the Aquifers of the Campania Plain (Italy)". *Am. J. Clim. Chang.* 2, 128-137.

[8] Jain, S. K. and Sharma, V., 2011. *Report on Contamination of Ground Water by Sewage*, Central Ground Water Board, Government of India.

[9] Census, 2011, Census of India-2011, Ministry of Home Affairs, Government of India, http://censusindia.gov.in/

[10] CGWB, 2011, Annual report 2010-11. Ministry of Water Resources, Government of India, http.//cgwb.gov.in/documents/Annual%20Report%202010-11.pdf

[11] Velagaleti, R. and Burns, P. K., 2006. "The Industrial ecology of pharmaceutical raw materials and finished products with emphasis on supply chain management activities", http://www.epa.gov/esd/chemistry/ppcp/images/ecology.pdf

[12] Report of the Working Group, 2011. *Sustainable Groundwater Management as input to 12th Plan*, Government of India, New Delhi.

[13] APHA, 2005. *Standard methods for the examination of water and waste water*, 21st Edn, American Public Health Association, Washington.

[14] WHO, 2006. *Guidelines of drinking water quality Recommendation*: the 3rd edition. Geneva: World Health Organisation, 2nd ed.

[15] Bureau of Indian Standards (BIS), 2012. *Drinking Water-Specification*, IS 10500:2012, Second Revision, Government of India, New Delhi.

[16] Ramakrishniah, C.R., Sadashivam, C. and Ranganna, G., 2009. "Assessment of Water Quality Index for the Groundwater in Tumkur, Karnataka State", India. *E. Journal of Chemistry*, 6(2), 523-530.

[17] Kavita, P. and Vineeta, P., 2010. "Evaluation Water quality Index for drinking purpose of river Subenarekha in Singhbhum District", *International Journal of Environmental Sciences*, 1(1), 77-81.

[18] Craun, G.F. and Mccabe, L.J., 1975. "Problems associated with metals in drinking water". *Journal of the American Water Works Association*, 67, 593.

[19] Salemi E., Mastrocicco M., Colombani N. and Aschonitis V.G., 2012. "Comparison of Three Different Methods for Groundwater Intrinsic vulnerability Mapping in the Ferrara Province", Italy. *BALWOIS* 2012-Ohrid, Republic of Macedonia.

[20] Howard, D., 2007. "Chemical Speciation Analysis of Sports Drinks by Acid–Base Titrimetry and Ion Chromatography: A Challenging Beverage Formulation Project" *Journal of Chemical Education* 84 (1), 124.

[21] Rahman, S., 2002. "Groundwater quality of Oman", *Groundwater Quality*, London, 122-128.

[22] Amadi, A. N., Olasehinde, P.I., Okosun, E.A. and Yisa, J., 2010. "Assessment of the Water Quality Index of Otamiri and Oramiriukwa Rivers", *Physics International* 1 (2), 116-123.

[23] Poonam B. and Ashokkumar V. 2013. "Assessment of physico-chemical parameters and water quality index of reservoir water", *International Journal of Plant, Animal and Environmental Sciences,* 3(3), 89-9.