PHYSICO-CHEMICAL PARAMETERS AND HEAVY METAL IONS IN GROUND WATER OF SRI GANGANAGAR

Smt. Veena
Lecturer in Chimestry
S.N.D.B. Govt. College, Nohar

Abstract

Water pollution affects plant and organisms living in these bodies of water. In almost all cases the effect is damaging not only to individual species and population but also to the natural biological communities water pollution is any chemical physical or biological change in the quality of water that has a harmful effect on any living things that drinks or uses. When humans drink polluted water it often has serious effect on their health. There are several classes of water pollutants. The first are disease causing agents. These are bacteria, viruses, protozoa that enter sewage system and untreated waste. A second category of water pollutants is oxygen demanding waste. Waste that can be decomposed by oxygen requiring bacteria. When large population of decomposing bacteria are converting these waste it can deplete oxygen levels in the water. Thus causes other organisms in the water, such as fish to die.

INTRODUCTION

Our earth is known as 'BLUE PLANET' because 4/5 of its surface is covered with water and on earth 96.5% of the planet water is found in oceans, 1.7% in ground water, 1.7% in glaciers and ice caps of Antarctica and a small fraction in other large water bodies and 0.001% in the air as vapour, clouds and precipitation. Only 2.5% of earth water is fresh water and 98.8% of that water in ice and ground water. Less than 0.3% of all freshwater is in rivers, lakes and the atmosphere and even smaller amount of the earth freshwater (0.003%) is contained with in biological bodies and manufactured product.

Safe drinking water is essential to humans and other life forms even though it provide no calories or organic nutrients. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack access to adequate sanitation.

Water play an important role in the world economy, as it function as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. Approximately 70% of the fresh water used by human goes to agriculture.

There are three main sources of water.

1. Rain

2. Surface water — Oceans, River, Streams, Tanks, Ponds and Lakes.

3. Ground water — Shallow wells, deep wells, springs.

1) Rain is the Prime source of all water. Rain water may be collected eg. on roofs but this water is also not used much.

2) Surface water is originates. from rain water. It is the main source of water supply in many area. Surface water is prone to contamination from human and animal sources. As such it is never safe for human consumption unless subjected to sanitary protection and purification before use. Many rivers furnish a dependable supply of water. The chief drawback of river water is that it is always grossly polluted and is quite unfit for drinking without treatment.

The river is an indicator of society standard. A dirty river means a dirty society & due to human activities such as producing on objectionable odour, excessive hardness and causing toxicity in water which affect polarity of water. Any human activity that imparis the use of water as a resource may be called water pollution. Water pollution occur when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compound.

Water pollution affects plant and organisms living in these bodies of water. In almost all cases the effect is damaging not only to individual species and population but also to the natural biological communities water pollution is any chemical physical or biological change in the quality of water that has a harmful effect on any living things that drinks or uses. When humans drink polluted water it often has serious effect on their health. There are several classes of water pollutants. The first are disease causing agents. These are bacteria, viruses, protozoa that enter sewage system and untreated waste. A second category of water pollutants is oxygen demanding waste. Waste that can be decomposed by oxygen requiring bacteria. When large population of decomposing bacteria are converting these waste it can deplete oxygen levels in the water. Thus causes other organisms in the water, such as fish to die.

A third class of water pollutant is water soluble inorganic pollutants. Such as acid, salts and toxic metals. Large quantities of these compound will make water unfit to drink and will cause the death of aquatic life.

Fertilizers and pesticides are major contributors to water pollution, nitrates from fertilizers are a common. Chemical pollutant of water heavy metal sulphate, phosphate,

pesticides, chloride, detergents, soaps are the common chemical pollutants. There are a number of pathogenic micro-organisms which cause water borne disease in man.

Bacteriological pollution of water is due to the presence of pathogenic bacteria, certain fungi, pathogenic protozoa, virus, parasitic worms etc. The important sources of bacteriological pollution are domestic sewage & industrial waste. Bacterial pollution in water is caused by the excretory products of warm blooded mammals including man, wild and domestic animals.

Biological pollution is also brought about by bacteria, viruses algae. Heavy organisms develop the ability to hover in water. They accumulate oils to forms mucilage, gas vacuoles etc. The growth of water used is very intense and water is said to bloom. Water bodies polluted with organic matter of plants and animal.

Physiological pollution of water is caused by several chemical agents such as chlorine, SO_2, ketones, phenols, amines, hydroxy benzene. Physically polluted water is unfit for drinking. Because physical pollution of water brings about changes in water with regards to its colour, odour, density & turbidity.

Colour change is not harmful unless it is associated with a toxic chemical, most of the trade wastes discharged into water system have pronounced colours due to organic dyes and inorganic complexes. Water also becomes intensely coloured due to interaction between naturally occuring components in water and trade effluents which make it unsuitable for various purposes. Turbidity in water mainly arises from colloidal matter, fine suspended particles. Generally greater the turbidity, stronger is the sewage and the industrial effluent concentrations and worst are effects. Turbid water becomes unsuitable for industrial purposes and also for domestic use Fe, Mn, Ni, Co, Pb, Sb etc. present in it may cause stains on clothes, sinks and baths etc. The turbidity due to bacterial contamination of sewage is most serious.

Pollution of water increasing rapidly due to rapid population growth industrialization, increasing living standard and wide sphere of human activities. In water there are some trace element which are essential in minute amount for human being while higher concentration of these element causes toxic effect.

REVIEW OF LITERATURE

In India, the problem of aquatic environment has become an important issue only very recently. Various scientist and scholars has done work in the field of water quality analysis. Some of them following are:-

Sidduqui A.H. (1955) analyzed fluoride content in Nalagende district. In these areas he found existence of high fluoride level: Due to this people were suffering with the dreadful disease of fluorosis.

M.C. Bell, T.G. Ludwig (1970) has reported that that fluoride in minute quantity is an essential for normal mineralization of bones and formation of dental enamel.

Bhatt and Hedge (1977) investigated ground water quality in Uttar Kannada district of Karnataka. They described that the chemical composition of most samples indicating as per drinking water quality prescribed by WHO.

Christie DP (1980) analyzed radiographic bone changes in children with fluorosis. They found that some radiographic changes suggestive of rickets, hyperparathyroidism and thalessemia were observed.

Kataria, H.C. (1994) analysed heavy metal contamination and pollution in Betwa river. They found that some heavy metal Cu^{+2}, Ni^{+2}, Pb^{+2}, Fe^{+3} and Mn^{+2} are outside the permissible limit according to WHO and Indian standard Choubisa et.al. (1995) analysed the fluoride content in domestic water resources of Dungerpur district of Rajsathan. They found endemic skeletal fluorosis along with crippling in tribes and their domestic animal in that area where fluoride content in drinking water is more than 3 ppm.

Zaheeruddin, Khurshid Shadab (1996) Usman Shabeer Md. analyseed the heavy metal pollution in parts of Delhi. For this they collect surface water sample and analysed various heavy metal and they found that most of the sample concentration of heavy metal exceed the max. permissible limit for drinking purpose prescribe by WHO.

Srinivas S. Vutukuru et.al. (2002) recorded BOD content ground and surface water of Gostani and Velpur canal of Tanuku town ranged from 107 to 110 mg/1 and 80 to 230 mg/I respectively. BOD values are high when compared to effluent discharge standard which indicate that the canal is polluted with organic matter is not potable.

Kataria & Dubey (2002) monitored the assessment of Cu^{+2}& Zu^{+2} in ground water of Bhopal & detected high conc. of Cu^{+2}& Zu^{+2} in all eighteen samples. It was concluded that zinc toxicity was due to galvanized pipes percolation of waste from industrial waste.

OBJECTIVE OF THE WORK

Water quality monitoring involves much more than quality surveillance. It involves survey surveillance and monitoring. Survey is an exercise to have observations from a single sampling location with in a stipulated period to generate qualitative and quantitative data. Surveillance involves a continuous programme of survey systematically undertaken to provide.

Information in time and space and monitoring is surveillance undertaken to assess the progress of targets and objectives.

The basic objectives for groundwater quality analysis of Sri Ganganagar are:

* To establish base line information for physico-chemical parameter trends and concentrations of Drinking Water.

* To evaluate Drinking Water quality in studied area for pH, conductivity Total Hardness, turbidity, chloride, sulphate, sodium, potassium , phosphate , Total alkalinity.

* Identification and demarcation of the potential zone of quality water.

* To recommend the remedial action and early working and detection of Drinking Water pollution.

SCOPE OF THE WORK

Water provides a unique medium to many physical, chemical and Biochemical reactions. Any minute change in water quality parameter may adversely and favorably affect the particular reaction as well as whole ecosystem (Vanloon 2002). So water chemistry has a keen scope for this project.

Much of literature has been reported for the effect of the water quality on human population. That is why analysis of the water quality of a particular geographical region has a great deal of interest. Water quality is directly affected by the geology of that particular region and water quality shows its own effect on biological system of that region (Montigomery 1989). So, if we are studying the biology of that particular region, we have to know water quality parameter, which provides many useful interpretations about the ecology population studies of that region.

So, this study will helpful to many water quality analysts as well as biologist, ecologist and environmentalists and also very useful to Public Health Department and Municipal Corporation to improve public health.

Table: Showing the Mean Value of Different Parameters of Tested Samples

Table: Showing the Mean Value of Different Parameters of Tested Samples

Sample Name	pH	TDS (Mg/l)	T.H. (Mg/l)	Ca^{+2} (mg/l)	Mg^{+2} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	Cl^{-} (mg/l)	F^{-} (mg/l)	SO_4^{-2} (mg/l)	NO_3^{-} (mg/l)	BOD (mg/l)	COD (mg/l)
S_1	7.60	235	86	63	5.6	12.03	21.64	48.64	1.5	44	10.5	0.434	300
S_2	7.63	125	86	69.3	4	12.89	21.71	35.46	1.5	41.6	12.2	0.434	400
S_3	7.07	152	88	60.9	6.6	13.53	21.57	29.27	1.47	37.3	15	0.434	325
S_4	7.64	175	84	60.9	5.6	13.36	21.62	42.55	1.58	39.3	30	0.869	340
S_5	7.38	242	82	63	4.6	13.04	21.56	35.46	1.58	34.8	48.5	0.434	260
S_6	7.48	215	76	60.9	3.6	19.83	21.51	40.41	1.57	31.2	52.5	0.869	275
S_7	7.84	495	86	61.2	4.5	16.49	21.58	38.62	1.57	29.2	30.9	0.869	380
S_8	6.98	652	74	63	2.6	16.59	21.54	42.12	1.42	24	40	1.3	250
S_9	6.98	125	90	71.4	4.5	18.2	21.7	27.17	1.48	21	32.5	0.869	400
S_{10}	7.56	220	92	84	1.9	18.2	21.68	41.67	1.45	19.2	12.5	0.434	290
S_{11}	8.02	195	86	71.4	3.5	16.83	25.22	28.39	1.48	19.7	10.7	1.35	260
S_{12}	7.38	185	80	75.6	1.0	17.27	24.83	29.27	1.52	17.2	5.6	2.60	320
S_{13}	8.02	556	94	69.3	6.0	16.49	26.32	35.46	1.54	13.7	15.7	2.17	325
S_{14}	7.74	105	94	71.4	5.5	18.98	26.32	48.46	0.80	13.0	15.9	0.869	400
S_{15}	7.31	152	82	62	3.2	13.04	21.34	35.46	0.70	24.0	15.7	1.35	275
Total	**112.63**	**3829**	**1280**	**1007.3**	**62.7**	**236.77**	**340.14**	**558.41**	**21.16**	**409.2**	**348.2**	**15.285**	**4800**
Mean Value	**7.5086**	**255.26**	**85.33**	**67.15**	**4.18**	**15.80**	**22.67**	**37.22**	**1.41**	**27.28**	**23.23**	**1.01**	**320**

RESULT AND DISCUSSION

The water quality of B-minor canal of Sri Ganganagar showing spatial variability in different localities. The variation in various parameter is as follows:

1. Colour & Odour

The physical character like appearance, colour, taste and odour are presented in table 5. In the present studies different samples collected from the various sites were clear in appearance tasteless and odourless. No objectionable odour or smell was noticed.

2. Turbidity

Turbidity is a measurement of the cloudiness of water, measurement by passing a beam of light through the water. Turbidity is water is due to colloidal and extremely fine dispersion suspended matter such as clay, slit, organic and inorganic matter.

The range for turbidity for these 15 sample lies between .22 to .98 NTU. The sample S_2 showed the lowest value of turbidity i.e. 22NTU and sample S_{12} showed the highest value of turbidity i.e. .98NTU. So all the sample showed the range with in the desirable limit as prescribe by WHO and we conclude that water of canal is very less turbid.

3. pH

pH indicate the intensity of acidic or basic character at a given temperature. Measurement of pH is one of the most important and most frequently used tests in determining water quality. Every phase of water treatment and water supply like acid base neutralization, coagulation etc. is pH dependent. According to WHO (1971), the desirable range of pH of drinking water is 7.0 to 8.5 and the permissible range of it is 6.5 to 9.2.

The pH of the range samples were found in the range of 6.98 to 8.0. Sample S_{11} and sample S_{13} shows the highest pH i.e. 8.0 and sample S_8, S_9 shows the minimum pH i.e. 6.98.

Only two sample S8 and S9 shows pH in the range 6.98 i.e. slightly acidic. This is because of waste products discharges to canal which contain acids. But remaining sample i.e. S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15} shows the alkaline range i.e. 7.07 to 8.0. Alkalinity may be due to use of fertilizers by villagers and due to presence of carbonate and bicarbonate.

Almost all the sampling points showed pH values within the desirable limit as prescribed by WHO (1971).

4. Electrical Conductivity

Electrical conductivity is the calculation of water tendancy to pass electric current through it. It indicate the total amount of dissolved salts. EC value for drinking water depends on the concentration of dissolved salt and ionic particles through which electric current passes.

	EC (μ mho/cm)	**Description**
1	< 250	Excellent
2	250 – 750	Good
3	750 – 2000	Permissible
4	2000 – 3000	Doubtful
5	> 3000	Unsuitable

The EC of different tested samples varies from .2 to .4 m mho/cm i.e. 200 to 400 μ mho/cm. So all samples are in range of 250-700 μ mho/cm, which is good.

5. T.D.S.

TDS is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular ionized or micro granular suspended form.

According to WHO the permissible limit of TDS of drinking water is 500 mg/l. TDS of different sample varied from 105 mg/1 to 652 mg/l. Sample S_{14} showed lowest range i.e. 105 mg/1 and sample S8 showed highest range i.e. 652 mg/l. Only two sample S_8 and S_{13} showed the range above the permissible limit and other remaining sample showed the range with in the permissible limit as prescribe by WHO.

A high contents of dissolve solid elevates the density of water reduces solubility of gases. The conc. of suspended particles rises due to bathing & washing of clothes.

6. Total Hardness

The total hardness is the sum of concentration of alkaline earth metal cations present in it. Calcium and Magnesium are the main cations imparting hardness however to a lesser extent cations like iron, maganese are also responsible for it.

According to WHO, the permissible range of total hardness is up to 500 mg/1 & highest desirable limit is 100 mg/l.

The total hardness of different sample varies from 74-94 mg/1. Sample S_8 showed the lowest value of total hardness i.e. 74 mg/1 and sample S_{13}, S_{14} showed the highest value of total hardness i.e. 94 mg/l. So all sample are in range of 100 mg/l. Which is desirable according to WHO.

	Total Hardness (mg/l)	**Description**
1	50 mg/l	Soft
2	150 mg/l	Moderately Hard
3	300 mg/l	Very Hard

From the above table, we can conclude that all water sample are in the range 150 mg/1 i.e. moderately hard.

Treatment

Reverse osmosis, ion exchange method or oxidizing filter can be used.

7. Calcium Hardness

Calcium is necessary because this is major cation used in bone formation. Its concentration varies greatly in natural water depending upon the nature of the basin. It is needed in especially large quantities by the mollusks and the vertebrates. Being an important contributor to hardness in water it reduces the utility of water for domestic use.

According to WHO (1971) the maximum permissible limit for calcium hardness of water is 100 mg/l. Calcium hardness of tested sample varies from 60.9 to 75.6 mg/1. Which is below the limit as prescribed by WHO for drinking purpose.

The sample S_3, S_4& S_6 showed the lowest value i.e. 60.9 mg/1 and sample S_{12} showed the highest value i.e. 75.6 mg/l. All value were within the permissible limit as prescribed by WHO.

8. Magnesium Hardness

Magnesium is a salt that contribute to the hardness and taste of water. Excessive magnesium may give bitter taste but is normally not a health hazard. Magnesium is a necessary constituent of chlorophyll without which no ecosystem could operate.

Magnesium hardness of different tested samples varies from 1.0 to 6.6 mg/1 sample S_{12} showed the lowest value i.e. 1.0 mg/I and sample S3 showed the highest value i.e. 6.6 mg/l.

The maximum permissible limit prescribed by WHO for magnesium hardness is 150 mg./1. And desirable limit prescribed by WHO for magnesium hardness is 30 mg/1. All sample are in range of 30 mg/1, which is desirable according to WHO.

9. Sodium

Sodium is the sixth most abundant element on earth and sodium ion is ubiquitous in water because of the high solubility of many sodium salts.

Sodium concentration of different tested sample varies from 12.03 to 18.98 mg/l. Sample S_1 shows the lowest value of sodium ion concentration i.e. 12.03 mg/1 and sample S_{14} shows the highest value of sodium ion conc. i.e. 18.98 mg/1. Sodium ion in range 20 mg/1 is necessary for proper muscle functioning. So all sample are in range of 20 mg/I, which is desirable according to WHO.

10. Potassium

Potassium as an nutrient and is essential for the body to properly function. Potassium works with sodium to maintain the body water balance & also involved in nerve function, muscle control.

Potassium concentration of tested sample is varies from 21.34 mg/1 to 26.32 mg/l. S_{15} sample shows the lowest value of potassium ion conc. i.e. 21.34 mg/1 and S_{13}, S_{14} samples shows the highest value of potassium ion conc. i.e. 26.32 mg/l.

The safe limit of potassium ion conc. is 12 mg/l. All of tested samples showed the range above the safe limit.

Potassium conc. varies with hardness of water. When high conc. of K^+ is accumulated on kidney. It may causes of irritation of eyes, nose, lungs. K^+ conc. in water may increases due to disposal of municipal waste.

11. Chloride

Chloride is generally present at low concentration in natural surface water. Chloride is an essential element and is the main extra cellular anion in the body. It is a highly mobile ion that easily crosses cell membrane and is involved in the maintaining proper osmotic pressure and acid-base balance. According to WHO (1971) the desirable limit for chloride is 200 mg/1 and maximum permissible limit for chloride is 600 mg/l.

Chloride ion conc. of different sample is varies from 27.17 mg/1 to 48.64 mg/1. Sample S_9 shows the lowest value of chloride ion conc. i.e. 27.17 mg/1 and sample S_1 shows the highest value i.e. 48.64 mg/l, which is much less than WHO desirable limit.

Thus canal water need treatment for using as drinking water because desirable chloride ion conc. is also important for purification of fine dispersed particles from water. So canal water needs chlorination treatment. Without chlorination canal water is not suitable for drinking.

12. Fluoride

Fluoride is an ion of chemical element fluorine with belongs to the halogen group. Fluoride essential is minute quantity for normal mineralization of bone and teeth, but when fluoride is taken up in excessive amount may toxic to human.

According to WHO the most desirable limit of fluoride ion is 1.0 mg/1 and maximum permissible range is 1.50 mg/I. Sample shows the range from .70 mg/1 to 1.58 mg/l.

The sample S_{15} shows the conc. in the lowest range i.e. .70 mg/1 and sample S_4 and S_5 shows the F ion conc. in the highest range i.e. 1.58 mg/l. All the sample shows value within the permissible limit as prescribed by WHO.

13. Sulphate

It is a non metallic element. It occurs naturally in water in concentration ranging from a few to several thousand mg/l. Sulphur is widely used for commercial and industrial purposes.

According to WHO (1971) the most desirable limit of sulphate ion is 200 mg/I and maximum permissible range is 400 mg/l. Sulphate ion concentration of different sample varies from 13 to 44 mg/l. Its value is within the permissible limit as prescribed by' WHO.

14. Nitrate

Nitrate is a compound of nitrogen and oxygen that is found in many food items. This is an important plant nutrient, but when present in excess it causes ubiquitous growth of algae. often present in blooms.

According to WHO, the desirable limit of sulphate ion concentration is 45 mg/1 and max. permissible range is 100 mg/l. Nitrate ion concentration of different sample varies from 5.6 mg/1 to 52.5 mg/1. The sample S_{12} shows the nitrate concentration in the lowest range i.e. 5.6 mg/1 and sample S_6 shows the nitrate concentration in the higest range i.e. 52.5 mg/l. So all the sample showed the range with in the permissible limit as prescribe by WHO (1971).

15. BOD

Biological Oxygen Demand BOD is the amount of molecular oxygen required for biological oxidation of organic matter. BOD means a measure of the approximate quantity of dissolve oxygen that will be required by bacteria to stablize organic matter in surface water. It is semiquantitative measure of the waste water organics that are oxidizable by bacteria.

For all tested sample the BOD value varied from .434 to 2.60 mg/I. sample S_1 , S_2, S_3, S_5& S_{10} shows the BOD conc. in the lowest range i.e. .434 mg/1 and sample S_{12} shows the BOD conc. in the highest range i.e. 2.60 mg/l. All samples shows BOD value within the limit prescribed by WHO.

16. COD (Chemical Oxygen Demand)

COD is a water quality measure used not only to measure the amount of biologically active substance, such as bacteria but also biologically inactive organic matter in water.

For all tested sample COD value varied from 250 mg/I to 400 mg/l. Sample S8 contain lowest amount of COD i.e. 250 mg/l and sample S_2, S_9, S_{14} showed highest range i.e. 400 mg/l. So its value is higher than the permissible limit as prescribed by WHO.

The increase in COD concentration was found in the bottom water where organic matter is more (Prasad & Qayyam, 1976).

COD increases due to toxic metals, waste material and waste treatment plant. It may causes the irritation of eyes, chances of high B.P., Kidney and Heart damage, Cancer and also damage central nervous system.

REFERENCES

Aggarwal, V., Vaish, A. K. and Vaish P. (1997), Ground water quality focus on fluoride and fluorosis in Rajasthan. Current Science, 73(9): 743-746.

Borgaonkat, S. S., Gokhble ,K. S. (1992), Distribution of Copper, Zinc, Cadmium and Lead in Thane creek and its relation with textural types and organic carbon. J. Environ. Bio. , 13(1): 39-45.

Bis (1993), Indian standard specification for drinking water is : 10500.

Choubisa, S. H., Sompuna, K., Choubisa ,D. K., Pandya H., Bhatt ,S. K., Sharma, O. P. and Parmal L. (1995) Fluoride content in domestic water sources of Dungerpur district of Rajasthan.Indian Journal of Environmental Health, 38(4): 236-241.

Dahiya, S., Kaur, A., Gory, V. Jain, N. (2000), Quantification of fluoride in ground water in rural area of Tosham subdivision, district Bhiwani-Haryana. Polln Res, 19 (3): 417-419.

Damodharan, V., Arutec Heivan, V. (2004), Ground water quality and soil characterization of municipal solid waste landfills. Pollution Research ,23 (2).

Das, B., Talukdar, J.,Sarma, S., Biren, G., Dutta, R. K., (2003), Fluoride and other inorganic constituents in ground water of Guwahati, Assam, India. Current Science, 85 (5).

Dayal, G. and Singh, R. P. (1991), Heavy metal contamination of ground water in Agra city (U.P.). Proc. Natl. Acad. Sci. (India), 61(A): 569-572.

Nag, T. K. and Das, A. K. (1992), Metal contamination of drinking water studied of Burdhwan district. India Journal for Environmental Protection, 12(9): 641-645.

Ozha, D. D., Bohra ,J. L., Jain, P. C. (1992), Ground waters quality in some arid region of Western Rajasthan. Proc. Int. Conf. Rural Water Supply Sanitation Developing Countries, Nagaur, 23-29.

Pallah, B. S., Bansal, M. L. and Sohota, H.S. (1991), Comparison of ground waters from shallow aquifers. Indian Journal for Environmental Protection, 35(1) 15-19.

Saha, A. K. (1991), Genesis of the arsenic in ground water in parts of West Bengal, centre std. Man Env., Annual 1:10.

Saha, L. C. and Panday, B. K. (1987), Quality of hand pump waters at Bhagalpur- A bacteriological quality. Acta Ecological 9: (1& 2).

Sahu, A., Vaishnav, M. M. (2006), Study of fluoride in ground waters around the BALCO Kobra area (India). Journal Environ. Sci. Engng., 48(1): 65-68.

Smithson, P., Addison, K. and Atkinson, K. (2002), Fundamentals of the physical environment. John willie and sons.

Swamy, Y. V., Roy, G. Ch., Das, S. N., Sengupta, S. and Muduli, R. (2005),Assessment of water quality in Tsunami affected,(A.P.). Current Science, 91(10).

Trivedi, P. (1988), Relationship between fluoride, total alkalinity, total hardness, in ground water of Pali district in arid and semi-arid region of western Rajasthan.58 (A): 7-11.

Tiwari, B., Mishra (2005), Evaluation of ground water quality in Rewa region, M.P., India.Ecol. Env. and Cons. 8(1): 133-136.

Vanloon, G. W. and Duffy, S. J. (2000), Environmental Chemistry, Oxford University Press, New York.

Vishwanath, G. and Anantha, K. S. (2004), Status of ground water quality. Pollution Research, 23 (2): 391-394