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Multivariate analysis of drinking water quality parameters around Gajraula industrial area, India

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Abstract

The present study aims at identifying the ground water contamination problem in the vicinity of Gajraula industrial area at Gajraula (U.P.) India. Ground water samples were collected by hand pumps and bore well, based on the depth of 40 and 120 feet of water table respectively. Analytical techniques were adopted in the standard methods for examination of drinking water quality in ground water samples and results were compared with the standards given by WHO and BIS guidelines for drinking water quality. The physico-chemical parameters like conductivity, TDS, Alkalinity, Ca, Mg-hardness and COD were recorded higher in comparison to standard values. The present study showed that drinking water quality of bore well water found slightly better than water of hand pumps.

Keywords: *Industrial pollution, Ground water, Drinking water quality*

Introduction

Water is an essential and vital component for life support system. Peoples around the world have used ground water as a source of drinking water and even today more than half the world's population depend on ground water for their survival (UNESCO, 2000). Water quality is an index of human health and better hygienic condition of society. Gajraula is a prominent industrial area of western Uttar Pradesh, owes its significance to diverse group of industries, which includes distillery and its associated chemical units, pulp & paper, phosphate fertilizer plant, textiles, pharmaceuticals, dairy and other units. The industrial effluents contain toxic chemicals, hazardous compounds, suspended solids and non-biodegradable materials. The major source of surface and ground water pollution is injudicious discharge of untreated industrial effluents directly into the surface water bodies resulting surface and ground water pollution described by Nasrullah, *et al.,* (2006) and Malik *et al.,* (2009). The ground water quality of hand pumps and bore well around industrial area has been affected a lot and causes serious disease among the human beings and other livestock population. Most of the labour class society generally depends on ground water of hand pumps for drinking as well as other domestic utilities. Hence, some scientific remedial measures should be taken to improve the drinking water quality in and around of industrial area.

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Materials and Method

Gajraula city is approximately 115 Km. away from Delhi on national highway NH-24, Delhi-Lucknow road. Gajraula is well known oldest industrial area of district J.P. Nagar (Uttar Pradesh), situated on globe at a longitude 78° 13'48.75" E and latitude 28° 50'59.26" N at 207 meter sea level. Gajraula industrial area was selected on the basis of existence of large number of industries (chemical units, pulp and paper, phosphate fertilizer plant, textiles, pharmaceuticals, dairy products processing units and others), which discharge a huge amount of wastewater in the form of mixed effluents through different drains, contributed to deteriorate the quality of surface and ground water. Ground water samples were collected by grab sampling method

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from hand pumps and bore well based on water table at depth of 40 feet and 120 feet respectively from different sampling sites of different villages adjoining the industrial zone. The ground water samples (n=120) were collected from each of hand pumps (HP n=5) and bore wells (BW n=5) from each sampling sites during the particular seasons (April-2008 to March-09). The water samples were analyzed by standard methods as APHA, (1998).

Results and Discussion

The ground water resources are now on the verges of threatened status in terms of sustainable quality of drinking water as well as contain various traceable toxic substances. The physico-chemical parameters of ground water of hand pumps and bore well were shown in Table -1 & 2. The minimum and maximum water temperature of bore well and hand pump water was observed as 18.33-27.69 ^{0}C during winter and summer seasons respectively. The influence in temperature may be due to different seasonal climatic variations and different sampling time (Parashar, *et al.,* 2008). The values of pH of hand pump and bore well water were recorded in the ranged from 7.26-8.05. The minimum value of pH was observed in bore well during winter season and maximum value of pH was also observed in bore well water during monsoon season. pH values of hand pumps and bore well water samples were within the permissible limit given by WHO. The minimum value of conductivity (924.97 µmho/cm) was observed in bore well water during monsoon season and maximum value of conductivity (1399.59 µmho/cm) was observed in hand pump water during winter season. The values of conductivity of hand pump and bore well water were recorded higher in comparison to standard value (400 mg/l) given by WHO.

Electrical conductivity with regards to water quality referred to the amount of salts in the water and is a numerical expression of the ability of an aqueous solution to convey an electric current. It is also an approximate indicator of total dissolved ions such as heavy metals and widely used for pollution monitoring (Nasrullah, *et al.,* 2006).

The present study showed TDS values were recorded in the range of 610.48-923.73 ppm. The minimum value of total dissolved solids was observed in bore well water during monsoon season and maximum value of total dissolved solids was observed in hand pump water during winter season. Drinking water with high total

Table-1: Physico-chemical characteristics of ground water of Hand pumps (HP)

Parameters	Summer	Monsoon	Winter	Mean
Temperature	23.41-27.69	23.73-25.95	18.61-23.92	23.75
pH	7.38-7.76	7.55-7.68	7.27-7.41	7.53
Conductivity	1157.66-1266.76	1221.26-1310.56	1174.98-1399.59	1212.20
TDS	764.06-796.42	806.03-864.97	775.48-923.73	797.75
Free-CO_2	0.680-0.843	0.152-0.247	0.254-0.570	0.392
Alkalinity	325.97-334.89	329.03-339.83	332.11-338.80	333.28
T. Hardness	274.90-282.87	253.62-271.86	269.52-282.35	275.17
Ca	170.67-175.33	152.67-178.27	163.20-183.78	170.43
Mg	102.74-112.20	94.07-113.50	99.10-111.41	104.81
DO	4.09-5.29	4.24-5.37	3.51-6.36	5.00
BOD	9.56-10.48	7.56-10.88	10.36-12.22	39.93
COD	22.43-23.17	22.42-23.71	24.54-25.62	23.68
Chloride	32.10-33.96	26.99-35.95	36.73-43.83	36.78
Potassium	4.94-5.40	5.16-6.08	4.75-5.57	5.42
Nitrate	4.34-5.07	5.81-6.05	6.43-7.24	5.78
Nitrite	1.06-1.13	1.55-1.75	1.87-193	1.56

Note: - All parameters are in ppm, except Temperature (^{0}C) and Conductivity (µmho/cm).

dissolved solids <500 ppm, (WHO, 2004) generally showed inferior potable quality and induced an unfavorable physiological reaction in the transient consumer and gastrointestinal infections (Jain, *et al.,* 2009). Kulshrestha, *et al., (*2002) also observed the similar range (840-1050 mg/l) of total dissolved solids in ground water Jaipur (Rajasthan) during summer season. The minimum value of alkalinity (260.17 ppm) was observed in bore well water during winter season and maximum value of alkalinity (339.83 ppm) was observed in hand pump water during monsoon season. Water with more than 200 mg/l value of alkalinity is not permissible for drinking as per WHO. The present values of alkalinity in the water of hand pumps and bore well have shown higher mark on permissible limit for potability of drinking water and contributed for degradation of ground water resources.

The high degree of water hardness can definitely be attributed to the disposal of untreated and improperly treated sewage and industrial wastes (Shanker, *et al.,* 2008). The minimum value of total hardness (230.64 ppm) was observed in bore well water during summer season and maximum value of total hardness (282.87 ppm) was observed in hand pump water during summer season . All the values of total hardness in hand pump and bore well water were recorded within the standard value (300 ppm) given by BIS. The maximum level of Ca-hardness was recorded 183.78 ppm in hand pump water during winter season and minimum level 129.68 ppm found in bore well water during summer season. The similar trend of calcium hardness occurred in ground water also reported by Ramakrishnaiah, *et al.,* (2009) and significantly correlated hardness of drinking water with health of human and other livestock population. The minimum value of Mg-hardness (94.07 ppm) was observed in hand pump water during monsoon season and maximum value of Mg-hardness (116.31 ppm) was observed in bore well water during winter season. The values of Mg-hardness were recorded higher in comparison to standard value (30 ppm) given by BIS.

The minimum value of dissolved oxygen (3.51 ppm) was observed in hand pump water during summer season and maximum value of dissolved oxygen (6.36 ppm) was also observed in hand pump water during winter season. The difference

Table-2: Physico-chemical characteristics of ground water of Bore wells (BW)

Parameters	Summer	Monsoon	Winter	Mean
Temperature	21.78-23.35	23.74-26.58	18.33-20.76	22.87
pH	7.44-7.87	7.38-8.05	7.26-8.04	7.63
Conductivity	925.45-1039.99	924.97-1006.69	949.97-1041.25	976.35
TDS	610.80-686.39	610.48-664.41	626.98-686.57	644.79
Free-CO_2	0.406-0.669	0.218-0.345	0.110-0.123	0.286
Alkalinity	265.58-282.40	277.57-301.30	260.17-276.31	278.80
T. Hardness	230.64-266.34	238.07-269.01	239.02-259.36	249.92
Ca	129.68-161.13	135.20-166.43	131.54-159.64	151.39
Mg	100.05-101.44	95.43-102.88	98.78-116.81	98.52
DO	4.78-5.25	4.83-6.21	4.71-6.23	5.41
BOD	6.68-8.07	5.61-8.63	5.35-8.20	7.00
COD	12.09-15.53	15.19-16.16	13.99-16.17	15.22
Chloride	19.91-24.41	22.43-23.48	20.23-23.76	21.96
Potassium	3.83-4.04	3.15-3.56	3.27-3.99	3.66
Nitrate	1.85-2.47	2.30-3.10	1.94-2.79	2.54
Nitrite	0.79-1.11	0.97-1.12	1.02-1.07	0.99

Note: - All parameters are in ppm, except Temperature (^{0}C) and Conductivity (µmho/cm).

between DO values in hand pump water and bore well water were found due to the depth level of ground water. Bore well water (deep water aquifer) having a least contamination in comparison to hand pump water (shallow water aquifer). The same range of DO (3.9-6.3 ppm) in industrial effluents affected ground water in Kancheepuram, also reported by Balakrishanan, *et al.,* (2008). The minimum value of free-CO_2 was observed 0.110 ppm in bore well water during winter season and maximum value of free-CO_2 was observed 0.843 ppm in hand pump water during summer season. All values of free-CO_2 of hand pumps and bore well water were recorded within the standard value given by WHO.

The BOD values of ground water samples denoted the present status of pollution load. The lowest value of BOD (5.35 ppm) was observed in bore well water during winter season and highest value of BOD (12.22 ppm) was observed in hand pump water during winter season. Biochemical oxygen demand (BOD) is inter-related with the levels of dissolved oxygen in the water. Organic compounds such as carbohydrates, proteins and fats, which can be a result of urban run-off, domestic sewage and industrial effluent are broken down by the micro-organisms present in the water and exerted an oxygen demand in aquatic system (Efe, *et al.,* 2005). The minimum value of COD (12.09 ppm) was observed in bore well water during summer season and maximum value of COD (25.62 ppm) was observed in hand pump water during winter season. All the values of COD in hand pumps and bore well water recorded high comparison than standard value (10 mg/l) given by WHO. The COD have not favored the permissible value of drinking water quality, which existed in ground water of villages located near to industrial area. Hence, the existed drinking water has been contaminated by the leaching industrial effluents and intermixing with ground water in aquifers.

Chloride occurs in all natural bodies in widely varying concentrations. The chloride content normally increases as the mineral contents increases (Dubey, 2003). The chloride levels ranged from 19.91 to 43.83 mg/l in bore well and hand pump water during summer and winter seasons respectively. Soil porosity and permeability also has a key role in building up to increase chloride concentration in ground water (Ramakrishnaiah, *et al.,* 2009). Excessive chloride in ground water indicated the un-potable characteristics of drinking water to impart bitter taste to water and corrode steel and may cause cardio-vascular problems among human society. The potassium content in both hand pump and bore well water were found in the range of 3.15-6.08 ppm. The minimum value of potassium was observed in bore well water during monsoon season and maximum value of potassium was observed in hand pump water during monsoon season. All the values of potassium in water samples come under the standard value (12 ppm) given by WHO. The minimum value of nitrate (1.85 ppm) was observed in bore well water during summer season and maximum value of nitrate (7.24 ppm) was observed in hand pump water during winter season (Table-1and 2). Beyond standard value (45 ppm, BIS), it may cause metheamoglobinemia or blue baby disease in infants. It may also be carcinogenic in adults (Basappa, 2003). The minimum value of nitrite (0.79 ppm) was observed in bore well water during summer season and maximum value of nitrite (1.93 ppm) was observed in hand pump water during winter season. All the values of nitrate and nitrite come under the standard value given by WHO.

Deleterious level of ground water pollution caused severe diseases in primary stages and slowly created a potential health hazards to the inhabitants of affected industrial area. The present study indicated drinking quality of bore well water observed slightly better than hand pump water. Therefore, the use of ordinary hand pumps should be discouraged for the direct consumption by peoples of industrial area. People dependent on hand pumps water are often to prone to health hazards due to polluted drinking water. The deterioration of ground water quality occurred due leeching processes of surface industrial waste water in water aquifers. At present most of the industries lacking of either independent waste water treatment facilities or common treatment

plant for purification of industrial waste water. The ground water resources must be non-contaminated, purified and treated efficiently on sustainable basis at point and non point sources of pollution level. The drinking water quality should be properly maintained and be available for human society to get healthy longer life.

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