Ground Water Pollution "A Case Study of Khetri Tehsil of Rajasthan"

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ABSTRACT

The ground water in the ancient times was considered to be fresh, but ground water pollution now received attention, since ground water quality is in decline. One of the important source and cause of ground water pollution, is industries, effluents and solid wastes (slag) from metallurgical plants. In the present report, an effort has been made to study the effects of effluent and solid waste (slag) on the surrounding ground water sources such as bore wells, open wells and supply water (tap water) of factory residential area and village area such as Kharkhada, Gothra, Manota, Singhana and residential area of KCC and Gothra. The parameters such as P^H, Conductivity, Total Hardness, Alkalinity, Chlorides, Phosphates and TDS were studied.The P^H values of sample collected for analysis showed remarkable variations (5.6 to 8.6). The lowest P^H is studied in the water sample collected from Kharkhada village near the tailing dam of Khetri Copper Complex. The low P^H can cause corrosion of water pipes. The conductivity of water sample studied show the highest value in the sample 2 and 4, which indicates the high amount of soluble salts and minerals. The water hardness is the measure of capacity of water to react with soap. The highest value of water hardness is noted in the well water samples of Gothra and Singhana (630 to 1106 mg/L) and tap water supplied to villagers of Gothra also showed hardness of about 560 mg/L, which is also not within permissible limit of hardness. The results indicated the pollution of ground water by the pollutants.

The total alkalinity of the water samples studied showed variations. The highest value of alkalinity is noticed in the well water samples and supply water (tap water) of Gothra village area (520 mg/L). Water less than 150 mg/L are considered soft water, while values greater than 200 mg/L are considered hard water. The high alkalinity may be associated with high P^H values, hardness and high dissolved solids and has an adverse effects on plumbing system especially on hot water systems. The amount of chlorides in the study area varies from 72 to 773 mg/L. The high chloride content can increase the conductivity of water and thus increases its corrosivity.The highest amount of phosphate is noted in the water samples collected from the area of solid disposal site of Khetri Copper Complex, which is also an indication of pollution. The TDS (Total Dissolved Solids) values studied in the water samples vary from 470 to 3490 mg/L. The highest value is noted in the samples collected from effluent flow area and solid disposal site of Khetri Copper Complex. The high TDS value can affect the general quality of water.

The results indicate that the disposal of industrial effluents and solid waste (slag) on land, which has limited capacity to assimilate the pollution load has led to ground water pollution. The study has clearly brought about the fact that the quality of well water has deteriorated significantly and the villagers depend on the drinking water supplied by the KCC to their residents.

KEYWORDS :-

Effluents, tailings, solid waste (slag), Smelter, P^H, conductivity, total hardness, alkalinity, phosphates, corrosion, pollutants, parameters, concentration.

INTRODUCTION

A man can survive without food for 40 days, but without water, his survival beyond 40 hours would be a miracle. Water can be a boon by way of potable water or a ban by causing serious health impacts. Therefore water to be potable should be safe and wholesome. Ground water in the ancient times was considered to be fresh, but ground water pollution now receives attention, since ground water quality is in decline. The important sources and causes of ground water pollution are sewage and other waste of domestic nature, industrial effluents, agricultural discharges and waste from thermal and nuclear power plants[1]. Among the chief sources of toxicants, the industrial effluents consists of a wide variety of substances of both organic and inorganic forms. The effluents are mainly coming out from breweries, tanneries, dying, textiles, pulp and paper mills and steel industries, electroplating and paint industries, mining operations etc[1]. These substances include oils, greases, plastics, suspended solids, phenols, acids, salts dyes, cyanides, metallic wastes and toxicants. Many of these substances are not easily degradable in nature and thus cause pollution problems[2]. Man lives on the surface of the earth and burrows underneath for mineral wealth. Extraction of mineral resources from the earth's crust is the key of the world economy as most of these minerals serve as raw materials for various industries[3].The environmental problem associated with the processes of extraction of mineral resources are the following:-

(i) Water pollution due to wash off overburden wastes, discharge of mine water, discharge of tailings in to the water bodies, acid mine drainage and coal washing operations.
(ii) Land degradation due to large scale excavation, disposal of mine wastes and tailings and subsidence.
(iii) Deforestation for construction of roads, fuel, food etc.
(iv) Disruption of water regime.
(v) Human environment problems (settlements, health and allied problems)
(vi) Problems of noise and vibration due to blasting and heavy machinery.

The contamination of the environment by concentrate or waste stored in the tailing dams or lagoons is a serious development affecting soil, food and organism in the aquatic ecosystems[4,5]. The ground and surface water in the vicinity of tailing pond is contaminated by heavy metals in the region of copper mining and smelting plant in Bor[6]. Similarly it is reported that effluents from smelter plants of NALCO (Orissa and Korba), Zinc smelter (Andhra Pradesh) also caused severe surface and ground water pollution[7,8]. Many studies have been reported on the effects of effluents, solid waste (slag) and emissions on the environment particularly on the surrounding water bodies[9-12]. The disposal of industrial effluents on land and/or on surface water bodies makes water resources unsuitable for other uses[13-15]. Apart from the disposal of industrial effluents on land untreated effluents and hazardous wastes also injected into ground water through infiltration ditches and injection wells in some industrial locations in India to avoid pollution abatement costs[16].

Instances of Industrial effluents disposal (mostly untreated or partially treated) on land for irrigation are very limited in developed countries like the USA, UK, Canada and Australia. In India having the option to dispose effluents on land encourages the industries to discharge their effluents either on their own land or on the surrounding farm lands in the hope that it will get assimilated in the environment through percolation, seepage evaporation without causing any environmental hazards. Environmental problems related to industrial effluent disposal on land have been reported from various parts of India and other countries. Disposal on land has become a regular practice for some industries and creates local/regional environmental problems[16-26]. Water quality problems related to the disposal of industrial effluents on land and surface water bodies are generally considered as a legal problem – a violation of environmental rules and regulations. However, Indian pollution abatement rules and regulations provide options to industries to dispose their effluents in different environmental media, e.g. on surface of water bodies, on land for irrigation, in public severs or marine disposal according to their location, convenience and feasibility. There are different prescribed standards for different effluent disposal options [CPCB.2001][7].

As far as industries are concerned, their objective is to meet any one of those standards, which is feasible and convenient for them to discharge their effluents. The standards are set with assumptions that the environmental media have the capacity to assimilate the pollution load so that no environmental problems will arise. However, when the assimilative capacity of the environmental media (surface water bodies or land) reach/cross the limits, large-scale pollution of surface water and ground water occurs. Such instances have been recorded from industrial clusters in various parts of country like Tamilnadu[27-29], Gujrat[30], Maharastra[22], Andhra Pradesh[14].The effect of effluents, tailing and solid waste (slag) of Khetri Copper Complex on the ground water regime is not studied. So an attempt has been made to study the effects of these on the surrounding ground water sources (Bore wells, open wells, and tap water in factory, residential and village area).

MATERIALS AND METHODS

Khetri Tehsil comes under Jhunjhunu district. Jhunjhunu district is located in the north-eastern part of Rajasthan. Khetri is located at 27.98^{o}N and 75.80^{o}E. It has an average elevation of 484 meters. Khetri Copper Complex is located 10 Kms away from Khetri. It was incorporated on 9th November 1967. It is an integrated multiunit copper producer in India in a wide spectrum of mining, smelting, refining and manufacturing of copper cathodes, wire loads and wire bars. Its production in the year 2008-09 was about 121759 metric tonnes of Copper and 14756 metric tonnes of H_2SO_4, was reported, and has annual production capacity of about 31-35 thousand metric tonnes of copper. According to the reports, the height of Chimney is about 375 ft and emission of smelter consists of SO_2 2% and effluent consists of total suspended solids (50%), Copper 0.15 ppm, Lead 0.1 ppm, Zinc 0.3 ppm, Sulphide 0.8%, Phosphate 0.3 ppm, Iron 0.4 ppm, Nickel 0.17 ppm, fluorides 1.2 mg/litre.

Collection of Samples :-

The water and effluent samples required for analysis were collected from different locations and were marked on the basis of the collection areas (Map-1).

Sample 1 :- Was collected from the wells located in the Kharkada village (Dhoop ledi) (5kms) which is the place where the tailing dam of Khetri Copper Complex is situated .

Sample 2 :- Was collected from the wells near to the solid waste disposal site (slag) of Khetri Copper Complex. It is located in the Gothra village (500 meters away from disposal site).

Sample 3 :- Was collected from the bore wells of Manota village, which is 3 kms away from the Khetri Copper Complex.

Sample 4 :- Was collected from the open wells situated very near to the effluent water flow of Khetri Copper Complex. It is located in Singhana region (2 kms away from Khetri Copper Complex).

Sample 5 :-Was collected from Khetri Copper Complex residential quarters situated very near to the premises.

Sample 6 :- Was collected from supply water of the Gothra village residential area.

Sample 7 :- The effluent water from Khetri Copper Complex was collected and marked as Sample 7.

The samples were collected from all the locations in clean 2 litres polythene cans. The analysis of water samples and effluents were done according to the methods described in APHA, 1985[31]. The parameters such as P^H, conductivity, total hardness, alkalinity, chlorides, phosphates and TDS were done and results of water samples were compared with WHO and Indian standards of drinking water quality criteria[32].

MAP - 1

SAMPLE LOCATIONS

RESULTS AND DISCUSSION

The present studies highlight the effect of effluent and solid wastes (slag) of Khetri Copper Complex on the surrounding ground water regime of Gothra, Kharkhada, Manota and Singhana villages of Khetri Tehsil of Jhunjhunu district. The parameters studied were P^H,Conductivity, TH (Total Hardness), Alkalinity, Chlorinity, Phosphate and TDS and are shown in Table-1 and Fig. 1-7. For the sake of clarity, changes in each parameters were discussed separately as follows :-

PH :-The PH value of the samples collected from different locations showed variations (Table-1 and Fig. 1). It varies from 5.6 to 8.5. The $P^H$of water is the measure of acid-base equilibrium and in most natural waters, is controlled by the carbon-dioxide-bicarbonate-carbonate equilibrium system. The lower P^H i.e. 5.6 was studied in the water sample collected from the Kharkhada village area which is very near to the tailing dam of Khetri Copper Complex. The low P^H may be due to the presence of mineral acids produced by the hydrolysis of salts of certain metals $FeCl_3$ or $Al_2(SO_4)_3$ present in the tailing dam. The desirable limit of P^H for drinking water is 6.5 to 8.5.

It is reported that at P^H levels of less than 7.0, occurred, releasing of metals in to the drinking water. However P^H is only one of a variety of factors affecting corrosion.

Conductivity :- The conductivity of water samples studied (Table-1 and Fig. 2) showed remarkable variations. A very low conductivity is seen in the water samples collected from residential area of K.C.C. and Kharkhada (1.02-1.12 mS/cm). The conductivity of well water samples 2 & 4 is 4.02 and 5.59 mS/cm respectively. The values showed are higher than the conductivity of water. The high conductivity of well water indicates the high soluble salt and minerals that have entered from the solid waste disposal site and effluent water flow area of Khetri Copper Complex.

Total Hardness :- The hardness is a measure of the capacity of water to react with soap. Almost all the samples of study area are showing hardness property except the K.C.C. factory residential area which is within the WHO permissible limit of hardness in drinking water (250 mg/L) (Table. 1 and Fig. 3). The highest value of hardness is studied in the well water samples of Gothra and Singhana (630 to 1106 mg/L) and tap water supplied to villagers of Gothra also showed a hardness of about 560 mg/L, which is also not within the permissible limit of hardness. The results indicate that the ground water and the tap water supplied is contaminated by surface pollutants.

Total Alkalinity :- Alkalinity is a measure of the presence of bi-carbonate, carbonate or hydroxide constituents and is the measure of a water samples ability to neutralize hydrogen ions. The total alkalinity of the water samples studied varies from 255 to 520 mg/L (Table. 1 and Fig. 4). The recommended range for drinking water is 30 to 400 ppm. The highest value of alkalinity is noticed in the tap water and well water samples of Gothra village area (520 mg/L). The alkalinity of other water samples are within the recommended range and it is reported that alkalinity usually associated with high P^H values, hardness and high dissolved solids and has adverse effects on plumbing system, especially on hot water systems. The reason for high total hardness and alkalinity in the ground water may be due to the percolation of haphazardly discharged industrial pollutants.

Chlorides :- Chloride in the form of Cl ions is one of the major inorganic anions in water. In potable water, the salty taste produced by chloride concentration is variable and dependent on the chemical composition of water. Some water containing 250 mg/L chloride may have a desirable salty taste if the cation is sodium. The chloride in the study area lies in the range of 72 to 773 mg/L. The permissible limit of chloride in drinking water is restricted to 250 mg/L. Only two samples showed the chloride concentration higher than the permissible limits (Table-1 and Fig. 5). It is reported that the chloride can increase the conductivity of water and thus increases its corrosivity (WHO).

Phosphates :-Phosphates enter into the water system through domestic and industrial effluents and agricultural run offs. Its high concentration is an indication of pollution. The amount of phosphates studies in the water samples ranges from 0.02 to 12.6 ppm/L. The highest amount is seen in the water sample collected from the area of solid disposal site of Khetri Copper Complex (Table-1 and Fig. 6).

Total Dissolved Solids :- The total dissolved solids concentration is the sum of cations and anions in the water. The total dissolved solids test is used as an indicator test to determine the general quality of the water. It affects the taste of water and water from different areas are characterized as tasteless, sweet, brackish, saline, bitter etc. TDS values in the water samples studied from different areas varies from 470 to 3490 mg/L. The highest value of TDS is noted in the samples collected from effluent flow area and solid waste (slag) disposal site. The tap water sample of KCC residential area showedthe TDS which is within the permissible limit of drinking water quality of WHO (500 mg/L). But the tap water supplied to the villagers of Gothra is above the permissible limit (1790 ppm) (Table-1 and Fig. 7s).

The continuous disposal of industrial effluents and solid waste on land, which has limited capacity to assimilate the pollution load, has led to ground water pollution. The drinking water wells of the villages located near the industry have a high concentration of chlorides, bicarbonates and other parameters such as conductivity, hardness, phosphates and total dissolved solids. The public water supply (tap water) of Gothra village studied has shown high level of TDS, hardness and conductivity, which are not in the permissible limit of drinking water quality criteria of WHO. The village people of Gothra do not have any other option besides depending on the drinking water, which has been supplied by the Khetri Copper Complex for their residents. These villagers line up at themselves at every door of the company quarters for merely a pot of drinking water, sometimes they are forbidden to get that much of water, this could be a serious threat in the future. Sustainable access to safe drinking water is one of the main targets of the United Nations Millennium Development goals, and indiscriminate disposal of effluents and solid waste (slag) on land make water resources unsuitable for drinking. Unlike developed countries, developing countries like India should follow the precautionary approach to protect the drinking water sources from point and non-point sources of pollution, as it cannot afford (financially and technically) to go for curative measures. Safe disposal of industrial effluents and solid wastes can support the achievement of this target.

TABLE -1

Water samples collected from different locations and the parameters studied

S.No.	Parameters	Sample Stations						
		Kharkhada 1	Gothra 2	Manota 3	Singhana 4	Effluents 5	Residential area of KCC 6	Supply water of Gothra 7
1.	PH	5.6	6.6	8.02	6.2	6.2	7.5	8.5
2.	Conductivity (mS/cm)	1.12	4.02	2.29	5.59	2.04	1.02	2.90
3.	Total Hardness (mg/L)	530	630	510	1106	440	250	565
4.	Alkalinity (mg/L)	470	520	360	340	125	255	520
5.	Chlorides (mg/L)	89	143	157	773	325	72	289
6.	Phosphates (ppm)	5.00	12.6	3.98	10.5	5.0	-	0.02
7.	TDS (ppm)	659	2840	1440	3490	1020	470	1790

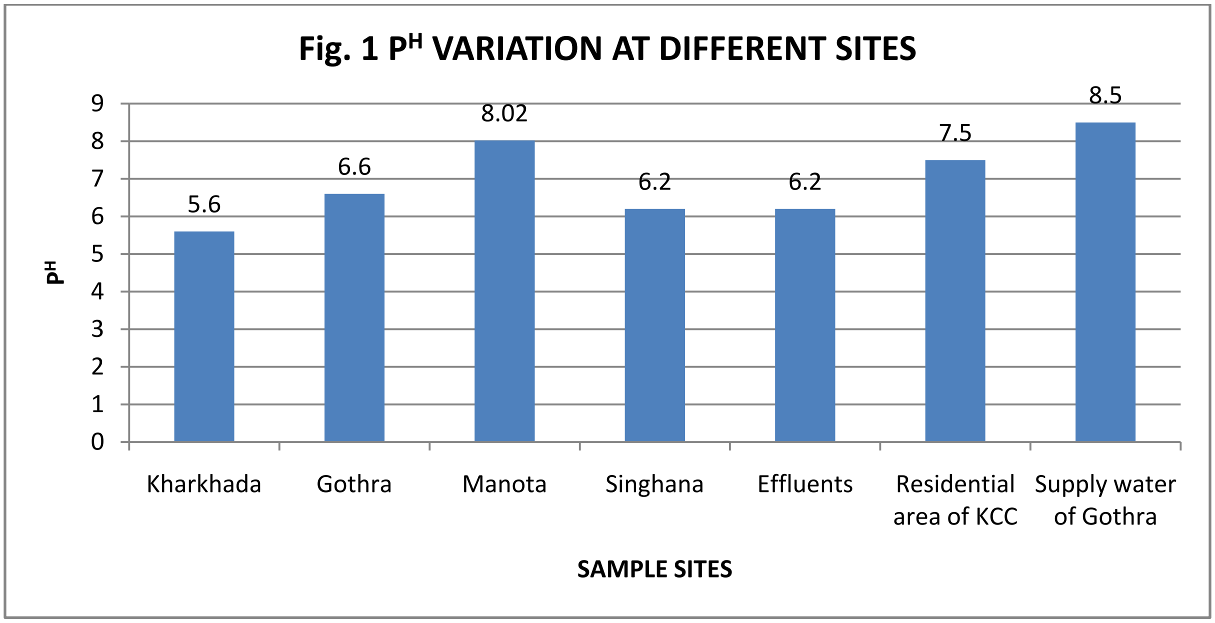


Fig. 1 P^H VARIATION AT DIFFERENT SITES
pH
9
8
7
6
5
4
3
2
1
0
5.6
6.6
8.02
6.2
6.2
7.5
8.5
Kharkhada
Gothra
Manota
Singhana
Effluents
Residential area of KCC
Supply water of Gothra
SAMPLE SITES

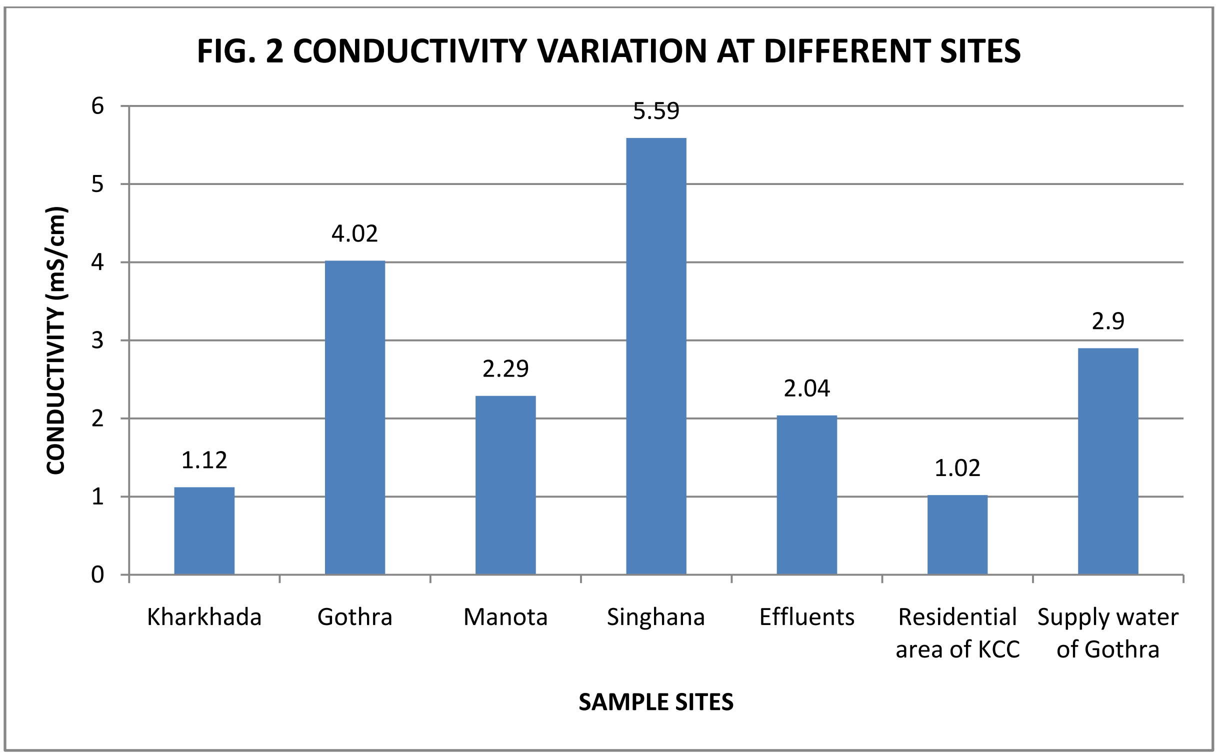


FIG. 2 CONDUCTIVITY VARIATION AT DIFFERENT SITES
CONDUCTIVITY (mS/cm)
6
5
4
3
2
1
0
1.12
4.02
2.29
5.59
2.04
1.02
2.9
Kharkhada
Gothra
Manota
Singhana
Effluents
Residential area of KCC
Supply water of Gothra
SAMPLE SITES

FIG. 3 TOTAL HARDNESS VARIATION AT DIFFERENT SITES

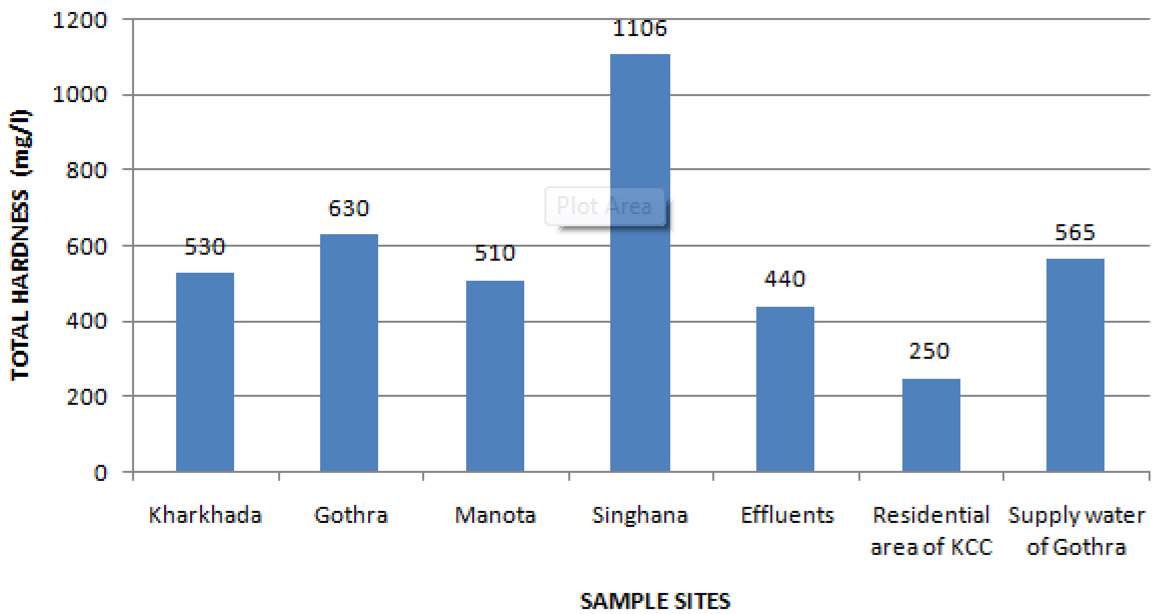


FIG. 4 ALKALINITY VARIATION AT DIFFERENT SITES

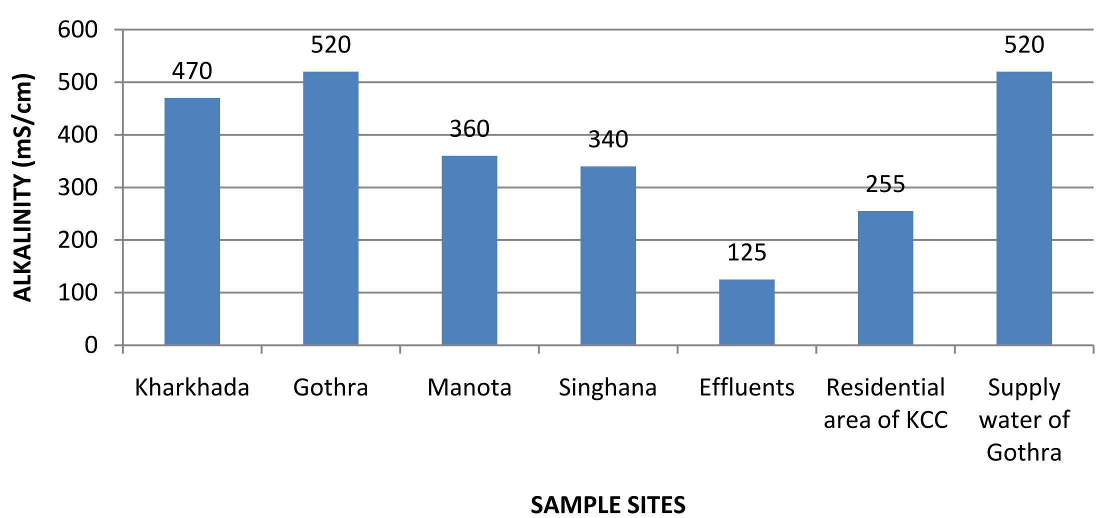


FIG. 5 CHLORIDE VARIATION AT DIFFERENT SITES

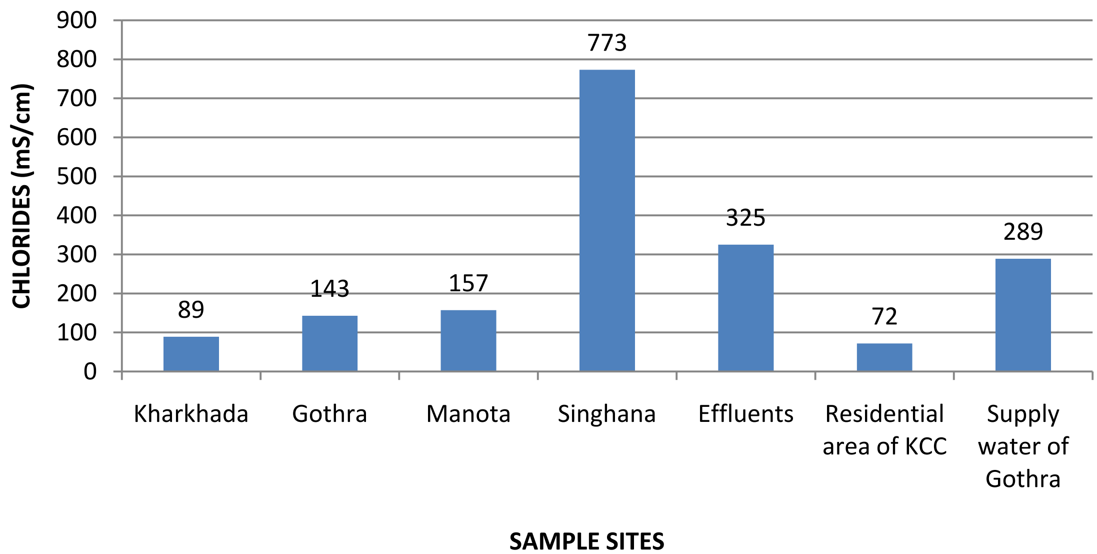


FIG. 6 PHOSPHATE VARIATION AT DIFFERENT SITES

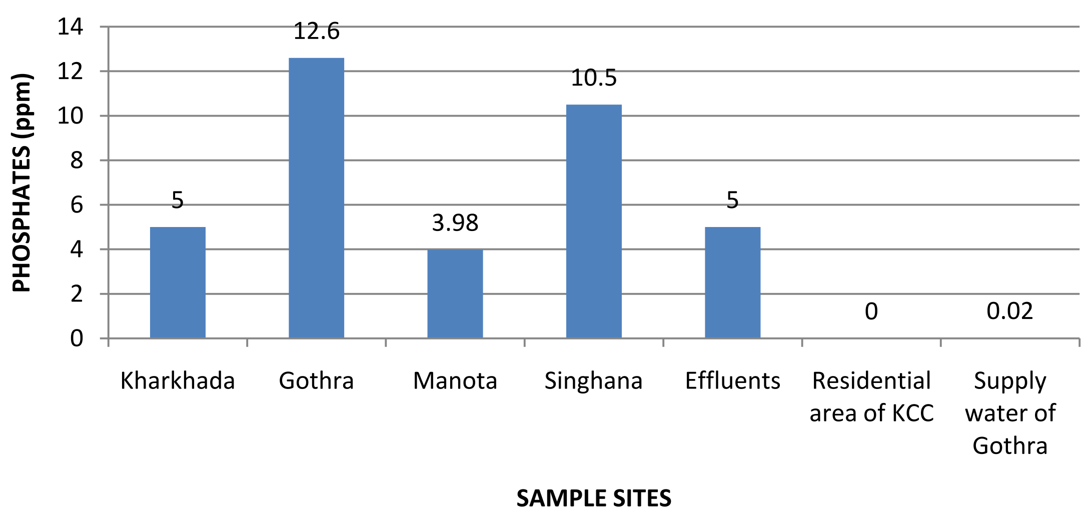
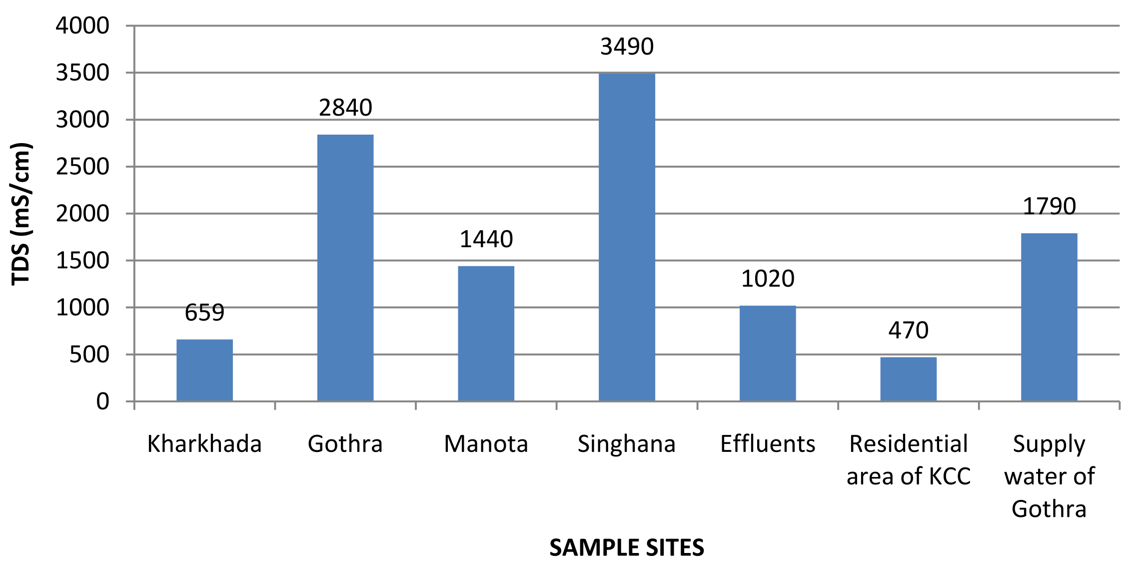


FIG. 7 TDS VARIATION AT DIFFERENT SITES



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