Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 4, Issue 5; April-June, 2017, pp. 351-355

http://www.krishisanskriti.org/Publication.html

Analysing the Environmental Impact on Ground Water by Oil Exploration–A Case Study in Sobhasan, Nandasan & Linch Fields of Mehsana Asset, ONGC, Gujarat

G L Das[1], R Sitaraman[2] and K Sravan Kumar[3]

[1,2,3]IPSHEM, ONGC, Goa
E-mail: [1]gadalaldas@gmail.com

Abstract—*Groundwater is an important water resource for domestic and agriculture in both rural and urban parts of India. Once polluted, a groundwater body could remain so for decades, or even for hundreds of years, because the natural processes of through-flushing are slow. In this study, 10 heavy metals were measured in ground water and produced water samples. It will help obtain information the impact of E&P activities on ground water quality with respect to heavy metals. Results were compared with drinking water standards which clearly show that the E&P operations are not contaminating the ground water in the study area.*

1. INTRODUCTION

Water is nature's most wonderful, abundant and useful compound. Of the many essential elements for the existence of human beings, animals and plants, water is rated to be of the greatest importance. Without food, human can survive for a number of days, but water is such an essential part of life that without it one cannot survive. Availability of quality freshwater is one of the most critical environmental issues of the twenty first century. Groundwater is an important water resource for domestic and agriculture in both rural and urban parts of India. The quantity and the suitability of groundwater for human consumption and for irrigation are determined by its physical, chemical and bacteriological properties. Two principal features of groundwater bodies distinguish them from surface water bodies. Firstly, the relatively slow movement of water through the ground means that residence time in ground waters are generally longer than in surface waters. Once polluted, a groundwater body could remain so for decades, or even for hundreds of years, because the natural processes of through-flushing are slow. Secondly, there is considerable degree of Physico-chemical and chemical interdependence between the water and the containing material. Monitoring of ground water regime is an effort to obtain information on ground water levels and chemical quality through representative sampling.

Due to inadequate supply of surface waters, most of the people are depending mainly on groundwater resources for drinking and domestic, industrial, and irrigation uses. Innumerable large towns and many cities in India derive water supply from groundwater for different uses through municipality network and also from large number of private boreholes. The groundwater is believed to be comparatively much clean and free from pollution than surface water. But prolonged discharge of industrial effluents, domestic sewage and solid waste dump causes the groundwater to become polluted and creates health problems. In recent years, because of continuous growth in population, rapid industrialization and the accompanying technologies involving waste disposal, the rate of discharge of the pollutants into the environment is far higher than the rate of their purification.

1.1 Ground water in Mehsana

In the Mahesana district ground water occurs in confined, unconfined and semi confined conditions. Groundwater is exploited in the area by deep tube-wells going beyond 400 m depth. Day-by-day groundwater condition is deteriorating in the area due to over exploitation. The withdrawal of ground water is 350 crore cubic meters per annum thereby creating an average annual deficit of ground water as 125 crore cubic meters. North Gujarat is the most stigmatic for the over withdrawal of ground water with water lift in many talukas particularly in Mahesana district having approached critical level of over 500 m. Due to over withdrawal of ground water, ground water table is going down by 2 to 4 meters per year.

1.2 Rainfall in Mehsana

Mahesana falls in semi-arid region having rainfall varying from 600 mm to 700 mm. Average rainfall in the district is about 642 mm. Less rain fall especially in North Gujarat is creating problem in agriculture and drinking water. Therefore, major source of irrigation is ground water. Only 15 % of the

rainfall percolates in the soil there by storing over 225 crore cubic meters of rain water annually as ground water. The rest flows away as runoff every year. In 1991 to 2014 the average normal rainfall of the district was about 737 mm (Figure 5). Rainfall in different parts of Mehsana District varies from 281 mm to 1421 mm with average number of 45 to 50 rainy days.

The present study was aimed to measure and monitor the ground water contamination in nearby areas where ONGC has been striving with its Exploration and Production activities in order to secure country's energy independence. This study will also help to determine the injection of various pollutants in to ground water sources due to other anthropogenic sources associated with many other industrial activities.

2. STUDY AREA

Exploration activity had started in Mehsana in 1964 and oil production commenced from 1969. Encompassing an area of 6000 sq. kms, Mehsana has 28 fields, 1414 oil wells and 15 gas wells (shown in fig.1) which produce about 6350 tonnes per day. There are total 38 installations in the Asset (GGS, CTF, ETP, In-Situ Compressor Plant, etc). Subsequently, it has emerged as the highest onshore producing Asset in ONGC. It produces light as well as heaviest crude in India with the average depth of a well in the range of 1100 m to 2200 m.

The core activities include oil and gas well drilling, integrated reservoir management and oil and gas production. Mehsana can proudly claim to be the pioneer of In-Situ combustion (thermal recovery technique) implementation at sub surface depths of 1000 to 1100 meters, which is probably first of its kind in the whole world. IOR schemes have also been implemented in these fields since the year 2000.

3. MATERIALS AND METHODS

In order to determine the effect of operations on the environment, notably on ground water quality, a simple and straightforward strategy was employed. Water samples were collected from nearby tube-well and compared against the produced water of the respective field. Produced water samples were collected from Sobhasan, Nandasan and Linch fields. Water samples were also collected from tube-wells located near these installations through grab sampling method. All the samples were collected after running the water for 2 to 3 minutes from the valve in a properly rinsed 1 litre Tarson bottle so as to avoid any kind of contamination which affects the quality of the sample. Then, the samples were acidified with 5% HNO3 solution. The samples were analysed for Barium (Ba), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Manganese (Mn), Nickel (Ni), Lead (Pb), Zinc (Zn) and Mercury (Hg) on Perkin Elmer make Inductively Coupled Plasma Optical Emission Spectrometer (model Optima 2000DV) and results are given in Table.1.

4. RESULTS AND DISCUSSION

4.1 Barium

In Sobhasan field, the concentration of Ba in produced water was 2129 µg/L and after ETP this was 1645 µg/L. The minimum value of Mn in bore-well water was 15.05 and the maximum was 20.12 µg/L and the average was 18.27 µg/L. In Nandasan field, the concentration of Ba in produced water was 701.2 µg/L and after ETP this was 493.7 µg/L. The minimum value of Ba in bore-well water was 3.91 and the maximum was 18.79 µg/L and the average was 9.14 µg/L. In Linch field, the concentration of Ba in bore-well water samples was between 1.65 and 23.83 µg/L. These values are much lower than the permissible levels as prescribed in Drinking water standard, 700 µg/L.

4.2 Cadmium

In Sobhasan field, the concentration of Cd in produced water was 0.98 µg/L and after ETP this was 0.78 µg/L. The minimum value of Cd in bore-well water was 0.05 and the maximum was 0.25 µg/L and the average was 0.12 µg/L. In Nandasan field, the concentration of Cd in produced water was 0.28 µg/L and after ETP this was 0.25 µg/L. The minimum value of Cd in bore-well water was 0.03 and the maximum was 0.13 µg/L and the average was 0.07 µg/L. In Linch field, the concentration of Cd in bore-well water samples was between 0 and 0.08 µg/L. These values are much lower than the permissible levels as prescribed in Drinking water standard, 10 µg/L.

4.3 Chromium

In Sobhasan field, the concentration of Cr in produced water was 0.13 µg/L and after ETP this was 0.45 µg/L. The minimum value of Cr in bore-well water was 1.25 and the maximum was 4.33 µg/L and the average was 2.70 µg/L. In Nandasan field, the concentration of Cr in produced water was 0.65 µg/L and after ETP this was 0.32 µg/L. The minimum value of Cr in bore-well water was 0.73 µg/L and the maximum was 3.63 µg/L and the average was 2.11 µg/L. In Linch field, the concentration of Cr in bore-well water samples was between 2.27 and 5.13 µg/L. These values are much lower than the permissible levels as prescribed in Drinking water standard, 50 µg/L.

4.4 Copper

In Sobhasan field, the concentration of Cu in produced water was 8.03 µg/L and after ETP this was 6.49 µg/L. The minimum value of Cu in bore-well water was 2.83 and the maximum was 8.81 µg/L and the average was 4.67 µg/L. In Nandasan field, the concentration of Cu in produced water was 7.99 µg/L and after ETP this was 10.69 µg/L. The minimum value of Cu in bore-well water was 2.45 and the maximum was 6.38 µg/L and the average was 3.61 µg/L. In Linch field, the concentration of Cu in bore-well water was between 2.97 and 3.48 µg/L. These values are much lower

than the permissible levels as prescribed in Drinking water standard, 50 µg/L.

4.5 Iron

In Sobhasan field, the concentration of Fe in produced water was 478.4 µg/L and after ETP this was 343.3 µg/L. The minimum value of Fe in bore-well water was7.61 and the maximum was 192.1 µg/L and the average was 54.21 µg/L. In Nandasan field, the concentration of Fe in produced water was 593 µg/L and after ETP this was 123.8 µg/L. The minimum value of Fe in bore-well water was 5.07 and the maximum was 21.24 µg/L and the average was 12.81 µg/L. In Linch field, the concentration of Fe in bore-well water was between 55.59 and 0.95 µg/L. These values are much lower than the permissible levels as prescribed in Drinking water standard of 300 µg/L.

4.6 Manganese

In Sobhasan field, the concentration of Mn in produced water was 31 µg/L and after ETP this was 4.1 µg/L. The minimum value of Mn in bore-well water was 0 and the maximum was 2.84 µg/L and the average was 0.71 µg/L. In Nandasan field, the concentration of Mn in produced water was 0.52 µg/L and after ETP this was 18.55 µg/L. The minimum value of Mn in bore-well water was 0 and the maximum was 1.12 µg/L and the average was 0.31 µg/L. In Linch field, the concentration of Mn in bore-well water samples was 0. These values are much lower than the permissible levels as prescribed in Drinking water standard, 100 µg/L.

4.7 Nickel

In Sobhasan field, the concentration of Ni in produced water was 6.62 µg/L and after ETP this was 5.54 µg/L. The minimum value of Ni in bore-well water was 5.98 and the maximum was 8.64 µg/L and the average was 7.20 µg/L. In Nandasan field, the concentration of Ni in produced water was 5.04 µg/L and after ETP this was 1.96 µg/L. The minimum value of Ni in bore-well water was 7.22 and 37 the maximum was 9.43 µg/L and the average was 8.43 µg/L. In Linch field, the concentration of Ni in bore-well water was between 4.95 and 6.93 µg/L. These values are lower than the permissible levels as prescribed in Drinking water standard of 20 µg/L.

4.8 Lead

In Sobhasan field, the concentration of Pb in produced water was 12.64 µg/L and after ETP this was 12.41 µg/L. The minimum value of Pb in bore-well water was 0.55 and the maximum was 5.63 µg/L and the average was 2.12 µg/L. In Nandasan field, the concentration of Pb in produced water was 7.93 µg/L and after ETP this was 3.75 µg/L. The minimum value of Pb in bore-well water was 0.64 and the maximum was 2.53 µg/L and the average was 1.43 µg/L. In Linch field, the concentration of Pb in bore-well water was between 0 and 3.95 µg/L. These values are lower than the permissible levels as prescribed in Drinking water standard of 5 µg/L.

4.9 Zinc

In Sobhasan field, the concentration of Zn in produced water was 1 µg/L and after ETP this was 1 µg/L. The minimum value of Zn in bore-well water was 1.86 and the maximum was 356.9 µg/L and the average was 91.48 µg/L. In Nandasan field, the concentration of Zn in produced water was 0.75 µg/L and after ETP this was 5 µg/L. The minimum value of Zn in bore-well water was 1.42 and the maximum was 6.53 µg/L and the average was 3.14 µg/L. In Linch field, the concentration of Zn in bore-well water was between 1.52 and 8.62 µg/L. These values are much lower than the permissible levels as prescribed in Drinking water standard of 5000 µg/L.

4.10 Mercury

In Sobhasan field, the concentration of Hg in produced water was 0 µg/L and after ETP this was 0 µg/L. The minimum value of Hg in bore-well water was 0 and the maximum was 5.37 µg/L and the average was 1.68 µg/L. These values are near the permissible levels as prescribed in Drinking water standard of 1 µg/L, except for the water sample 3 from SOB ETP BW water where it was found to be 5.37 µg/L. In Nandasan field, the concentration of Hg in produced water was 0 µg/L and after ETP this was 0 µg/L. The minimum value of Hg in bore-well water was 0 and the maximum was also 0 µg/L and the average was 0 µg/L. In Linch field, the concentration of Hg in bore-well waters was 0 µg/L. The permissible levels as prescribed in Drinking water standard of 1 µg/L.

5. CONCLUSIONS

14 water samples of which, 10 are ground water samples from Sobhasan field (4), Nandasan field (4) and Linch field (2) nearby localities. Rest 4 samples are, SOB ETP inlet water(1), SOB ETP outlet water(2), Nandasan Inlet ETP Water(8) and Nandasan Outlet Water(9), produced waters from oil and gas wells. The heavy metal concentrations in all these 14 samples are presented in table.1. This shows that Barium concentration is on the higher side of all the four produced water samples collected from Sobhasan and Nandasan. Whereas, the ground water samples from Sobhasan and Nandasan showed much lower values in respect of Barium (with reference to IS 10500 – 2012). The concentration of Lead and Iron was higher at sample no.1, 2, and 8 as compared to the ground water samples collected from bore-wells from nearby area. However, ground water samples from Sobhasan and Nandasan area showed much lower values in respect of Iron. All other metals like Cadmium, Chromium, Copper, Manganese, Nickel, Zinc and Mercury are having concentrations which are less than the drinking water standard (IS 10500 – 2012). This clearly shows that the produced water is not mixing with the ground water. In other words, the exploration and production

operations are not contaminating the ground water in Sobhasan, Nandasan and Linch areas.

6. ACKNOWLEDGEMENT

Authors thank ONGC's management for encouraging for the preparation and presentation of this paper. They also wish to acknowledge ED-HoI, IPSHEM for his continuous guidance.

REFERENCES

[1] Nickel in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality, 2007

[2] Evaluation of ground water conditions of Mehsana, Gujarat, India using Geoinformatics Technology (IJSRD/Vol. 3/Issue 03/2015/001)

[3] Gujarat Environment Management Institute (GEMI), Report 3, Mehsana District

[4] Hazards of heavy metal contamination, British Medical Bulletin, Volume 68, Issue 1, pp 167-182

[5] Human Health Effects of Heavy Metals, Environmental Science and Technology Briefs for Citizens, Center for Hazardous Substance Research, Kansas State University, Issue 15, March 2009

[6] ICP – Optical Emission WinLab32 Instrument Control Software, Perkin Elmer, USA

[7] Mercury in the Environment, Fact Sheet 146-00 (October 2000), USGS

Table 1: Heavy metal concentrations in water samples

Station No.	Barium	Cadmium	Chromium	Copper	Iron	Manganese	Nickel	Lead	Zinc	Mercury
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1 SOB ETP inlet water	2129.00	0.98	0.13	8.03	478.40	31.49	6.623	12.64	1.17	0.00
2 SOB ETP outlet water	1645.00	0.78	0.45	6.49	343.30	4.05	5.535	12.41	1.02	0.00
3 SOB ETP Bore Well Water	20.12	0.25	4.33	8.81	192.10	2.84	5.977	5.63	356.90	5.37
4 Punasan borewell water # 1 (near SOB#153 - Water Injection Well)	15.05	0.12	3.04	3.47	7.61	0.00	8.452	1.62	4.67	1.18
5 Punasan BW # 2 (near Well SOB # 12)	18.93	0.05	2.19	2.83	7.75	0.00	8.643	0.55	2.47	0.15
6 Punasan BW# 3 (near Well SOB # 87)	18.99	0.06	1.25	3.55	9.38	0.00	7.952	0.66	1.86	0.00
7 Borewell water near Nandasan GGS	4.43	0.03	1.40	6.38	21.24	1.12	8.812	0.64	6.53	0.00
8 Nandasan Inlet (NKETP Water) ETP	701.20	0.28	0.65	7.99	593.00	0.52	5.041	7.93	0.75	0.00
9 Nandasan Outlet (Injection Water)	493.70	0.25	0.32	10.69	123.80	18.55	1.961	3.75	5.00	0.00
10 Nandasan BW # 1 (near Well No #58)	9.44	0.13	2.66	2.77	14.19	0.10	9.434	2.53	1.42	0.00
11 Nandasan BW# 2 (Well No # 24 – inj)	3.91	0.07	0.73	2.45	10.72	0.00	8.253	1.81	2.89	0.00
12 Nandasan bw# 3 (No # 68 –Inj water)	18.79	0.03	3.63	2.83	5.07	0.00	7.216	0.72	1.71	0.00
13 Linch GGS Borewell Water	1.65	0.00	2.27	2.97	55.59	0.00	6.927	3.95	1.52	0.00
14 Borewell water near Linch GGS	23.83	0.08	5.13	3.48	0.95	0.00	4.952	0.00	8.62	0.00

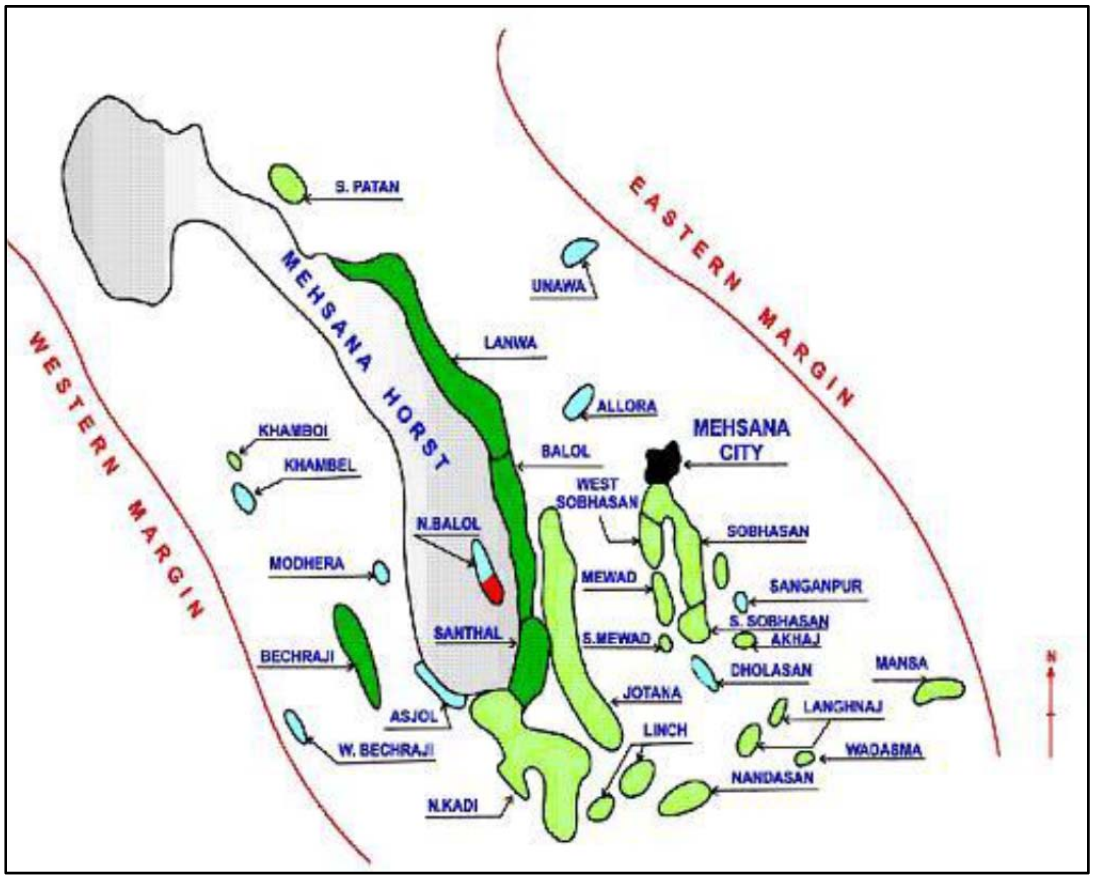

Fig. 1: Mehsana Asset

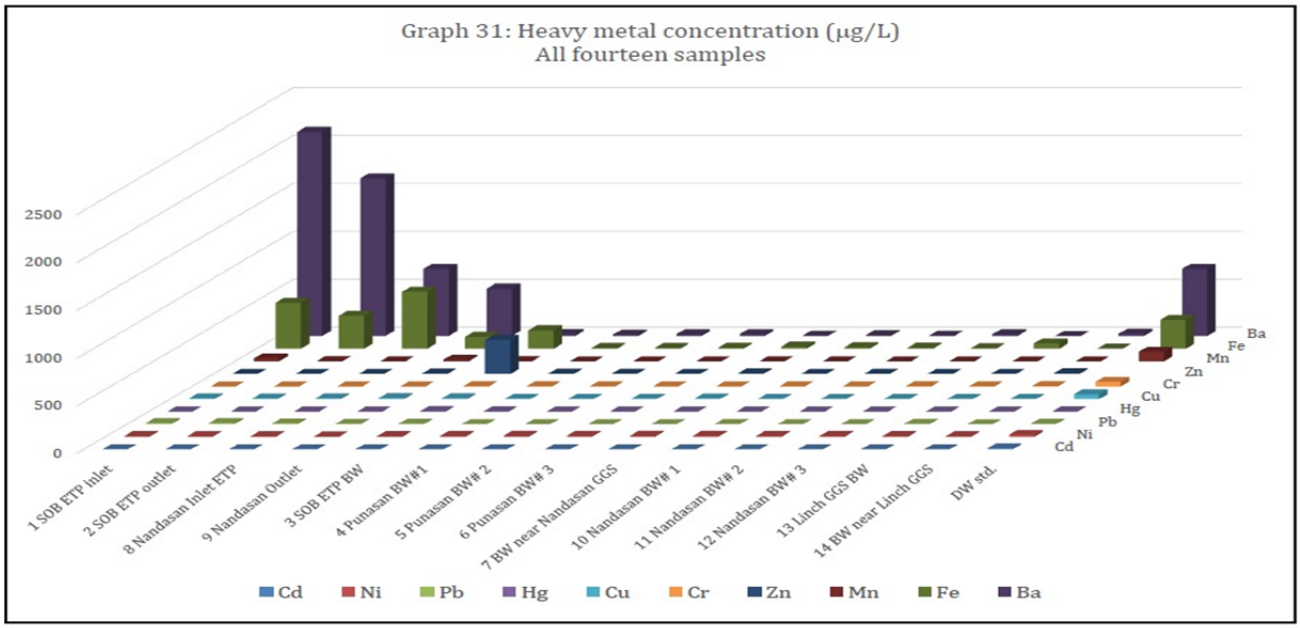

Fig. 2: Graphical representation of metal concentrations in water samples