# Assessment of Ground Water Quality in Designated Peenya Industrial Area and Estate, Bangalore, India – A Case Study

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***Abstract-*** **The study of underground contamination will be of immense help to researchers and environmental regulators to evolve and initiate mitigative measures. Peenya Industrial Area, Bangalore, India is considered to be one of the oldest and largest industrial areas in south-east Asia. Studies have been carried out to identify the parameters of contamination and their distribution with the help of the existing bore wells which have been analyzed for 20 parameters. The major general contaminants found exceeding standards are hardness and nitrates; whereas, hexavalent chromium and lead are toxic elements found exceeding the drinking water limits in some bore wells. However, the bore wells containing the parameters exceeding the limits were found highly isolated spatially in the entire area except an isolated presence of chromium in one pocket, thus indicating that the situation is not serious and can be tackled by initiating measures to control local stretches. Combination of parameters exceeding limit varied from bore well to bore well**.

***Keywords- Contamination; Hardness; Nitrates; Heavy Metals***

## I. INTRODUCTION

Long and sustained industrial activity in any given area can often lead to soil and ground water contamination. Improper waste disposal practices might contaminate the soils and gradually the entire ground water in the area, impairing ground water quality for many applications including drinking. The study of underground contamination will be of immense help to researchers and environmental regulators working in the area to understand and evolve by initiating remedial measures. The detrimental alteration of the naturally occurring physical, thermal, chemical, or biological quality of groundwater is called ground water contamination [1]. Groundwater pollution works differently from surface water pollution. Unlike surface water, ground water does not typically flow toward a single outlet at the topographic bottom of the watershed, whereas the cumulative effect of watershed pollution and improvements in watershed management can be directly measured. Groundwater discharge depends on topography (mountainous, hilly, or flat), and hydrogeology (confined or unconfined aquifers, fractured rock or sediments, aquifer geometry).The most prevalent forms of groundwater pollution are from non point sources [2].

Ratnakar Dhakate *et al*. [3] have studied the impact of ground water due to opencast chromium mining in Sukinda valley, Orissa, India and have found high level of TSS, Cu, Fe and Cr in groundwater. Nassef *et al*. [4)] assessed the heavy metal concentration in the soil and the groundwater of Sadat City in Egypt and its influence due to the highly developed industrial activities in that area. The levels of Pb, in the ground water wells are reportedly above the Egyptian and the WHO guide lines in three wells in the industrial area. Adelekan *et al*. [5)]have studied heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria and found that when compared to the limits set by WHO for drinking water, heavy metals with the exception Cu were higher than the limits. Sachitananda mukarjee *et al* [6] have studied ground water pollution at Mettupalyam taluk, India and found that continuous disposal of industrial effluent on land which has limited capacity assimilating to the pollution load has led to ground water pollution.

Peenya, Bangalore, India is considered to be one of the oldest and largest industrial areas in south-east Asia. Peenya industrial estate was established in late 1970s by the Karnataka Small Industries Development Corporation as Stage 1, 2 and 3. Karnataka industrial Area Development Board developed Phase 1, 2 and 3. Total extent of area is about 10 sq. K.M. The industries which are significant from water pollution point of view are engineering with surface treatment, formulation, drugs, pesticides, garment Washing and textiles. In addition, effluents from industries in the unorganized sectors located around the industrial area and domestic sewage are also major sources of pollution. A study by the Mines and geology department, Karnataka, India [7], the bore wells adjacent to Peenya industrial area have found heavy metals, including zinc, copper, lead, manganese, chromium and aluminum, beyond permissible limits. Shankar *et al* [8] have studied impact of industrialization on groundwater quality in Peenya industrial area by collecting groundwater samples from 30 different locations The investigations reveal that most of the study area is highly contaminated due to the excessive concentrations of one or more water quality parameters such as nitrates, total hardness, calcium, magnesium, total dissolved solids, sulphates and fluorides, which have rendered nearly 77% of the water samples tested, non- potable. Charmaine Jerome1 *et al* [9] has carried out analysis of bore well waters adjacent to Peenya industrial area and found that most of the water quality parameters were beyond the permissible limits and recommended for comprehensive sewerage system for safe disposal by which wastes should be developed to safeguard groundwater quality Raju, *et al* [10] has conducted study on emerging ground water crisis in urban areas of Bangalore and conducted ground water analysis at various places and concluded that the total dissolved solids and nitrates are high in the ground water in certain areas of Bangalore including Peenya industrial area indicating seepage of municipal sewage into the ground water. The data available on ground water contamination in Peenya is limited, vague and not comprehensive. Hence, an attempt was made to study the ground water quality assessment of the entire Peenya industrial area and to identify the contaminated bore wells which are beyond permissible limits for drinking water and also the parameters which are significant contributor for pollution in the area. Depending on the type and extent of contamination remedial approaches can be evolved. For this purpose a strategy was drawn to collect ground water from the existing bore wells (84) in the designated industrial area. Considering all possible sources of contamination various parameters have been selected for analysis.

## II. DESCRIPTION OF THE STUDY AREA

Bangalore is located at a Lat. of 12°58' N and Long 77°35' E at an altitude of 921 m above mean sea level [11]. The Peenya industrial area is located on the north-western suburbs of Bangalore city between 13°1'42"N and 77°30'45"E. industrial area/estate is surrounded by residential and private heterogeneous industrial activity. There is no buffer zone existing between designated Peenya Industrial Area/estate and surrounding area. Average recorded rain fall for Bangalore city in the last 20 years has been 1055.45 mm. The industrial area in general is witnessed by a red sandy soil. The soil cover extends upto 1 to 2 meters below the ground level. It is porous, non sticky and non clayey. This area is located on a highly undulating terrain. The highly undulating topography with dendritic nature has given rise to the origin of many micro water sheds with varying hydrological characters. Based on the prevailing topography, three prominent micro water sheds can be identified in the Peenya Industrial Area, namely Shivapura micro water shed, Chokkasandra micro water shed and Goragutepalya or Laggere micro water shed.

## III. MATERIALS AND METHODOLOGY

Detailed survey was conducted to identify the number of existing bore wells. The survey was conducted by visiting each industrial plot and identifying the existence of bore wells.

The area/stage wise bore well locations are indicated in Table I.

TABLE I DISTRIBUTION OF BORE WELL IN STUDY AREA

| Area | Nos |
|---|---|
| Stage-1 | 04 |
| Stage-2 | 03 |
| Stage-3 | 01 |
| Phase-1 | 13 |
| Phase-2 | 23 |
| Phase-3 | 23 |
| Phase-4 | 17 |
| Total | 84 |

### *A. Sampling Method*

The samples were collected during the month of October, 2010. 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.

### *B. Analyses*

The samples were analyzed for pH, dissolved solids, sulphate, chloride, cyanide, lead, copper, hexavalent chromium, zinc, manganese, iron, cadmium, nitrate as $NO_3$, phenolic compounds, total hardness as $CaCO_3$, calcium as Ca, magnesium as Mg, fluoride, turbidity. The samples were analysed as per Standard methods for the examination of water and waste water, 21st Edn, APHA, Washington (2005) [12]. The results obtained were compared with the drinking water standards as specified by Indian Standard IS: 10500-1991.

### *C. Location Map*

The location map of bore wells if given Fig. 1.

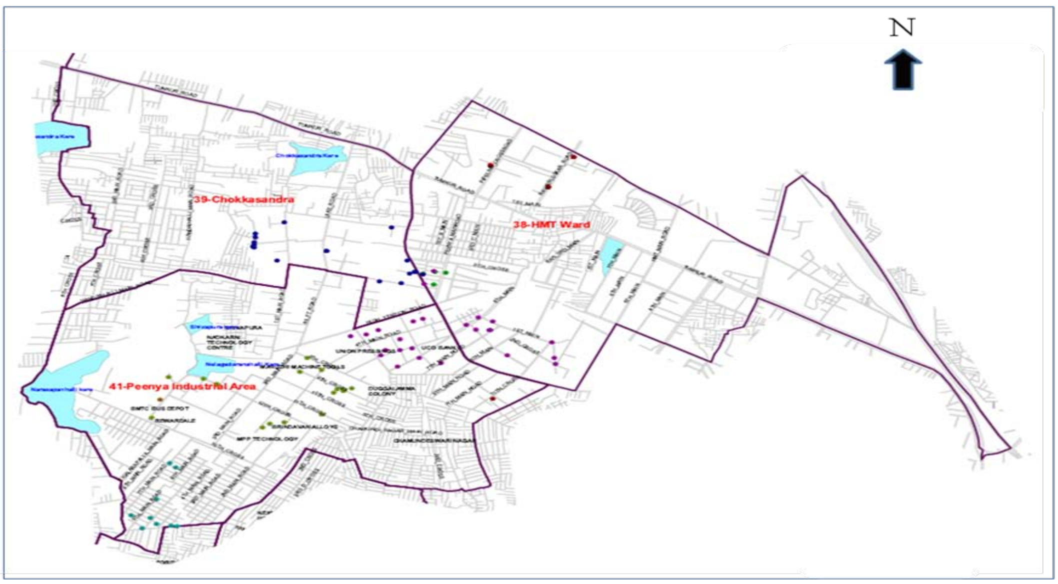


Fig. 1 Location of bore wells

## IV. RESULTS AND DISCUSSIONS

Results and analysis are presented in Table Ⅱ, and compared with the permissible drinking water standards specified by Indian Standard Specification as per IS: 10500-1991 and the number of samples exceeding the limits parameter wise and their values are given.

TABLE Ⅱ RESULTS OF WATER ANALYZED IN COMPARISON WITH STANDARDS

| Parameter | Permissible Limits as per IS10500:1991 | Concentration Observed | | No of Samples Exceeding the Limit | The Concentration Exceeding the Permissible Limits |
|---|---|---|---|---|---|
| | | Minimum | Maximum | | |
| pH | 6.5 -8.5 | 6.1 | 8.42 | 4 | 6.48, 6.16, 6.36, 6.1 |
| Dissolved solids | 2000 | 232 | 2310 | 2 | 2178, 2310 |
| Sulphates | 400 | 10 | 810 | 1 | 810 |
| Chlorides | 1000 | 36 | 900 | - | - |
| Lead | 0.05 | BDL | 0.8 | 10 | 0.8, 0.31, 0.06, 0.51, 0.14, 0.06, 0.11, 0.18, 0.19, 0.07 |
| Cyanide | 0.05 | BDL | Not found | - | - |
| Copper | 1.5 | BDL | 0.88 | - | - |
| Hexavalent chromium | 0.05 | BDL | 32.5 | 12 | 32.5, 0.77, 4.59, 0.36, 0.13, 0.84, 21.6, 0.19, 0.68,5.7, 0.06,1.34 |
| Zinc | 15 | BDL | 1.85 | - | - |
| Manganese | 0.3 | 0.03 | 3.38 | 4 | 2.09, 1.96, 0.57, 3.38 |
| Iron | 1.0 | BDL | 0.55 | - | - |
| Cadmium | 0.01 | BDL | Not found | - | - |
| Nitrate as $No_3$ | 45 | BDL | 200 | 22 | 105, 59.3, 73.6, 77.28,59.1, 55.72, 63, 62, 200,200 62.72, 70.6, 52.4,116,56.5,54.6, 125.4, 48.26, 87, 57,76,61.6 |
| Phenolic compiounds | 0.002 | BDL | Not found | - | - |
| Hardness | 600 | 169 | 1192 | 32 | 718,631,626,1046,674,1192,1035,762,687, 763, 800,806,1189,887,800,1028,928,713,768, 625,856,683,646,623,1084,654,728,630,748,744,708,654 |
| Calcium as Ca | 200 | 11 | 279 | 6 | 206, 203, 279, 219, 211, 215 |
| Magnesium as Mg | 100 | 25 | 188 | 12 | 157, 102, 111, 111,188,108, 125, 161,103, 132,164, 156 |
| Flouride | 1.5 | BDL | 1.5 | - | - |
| Turbidity | 10 | 1 | 16 | 6 | 16, 13.4, 14.3, 16, 13.7,13.1 |
| Alkalinity | 600 | 130 | 461 | - | - |

Note – all parameters except pH and turbidity are in mg/L

### *A. Observations Drawn from the Data Presented in Table Ⅱ*

1. pH- Ranges between 6.1 and 8.42. Four samples are exceeding the permissible limit of 6.5-8.5. All the four samples exceeding the limit are slightly acidic.

2. Dissolved solids- Ranges between 232 mg/L and 2310 mg/L. Two samples are exceeding slightly the permissible limit of 2000 mg/L.

3. Sulphates- Ranges between 10 mg/L and 810 mg/L. One sample is exceeding the permissible limit of 400 mg/L. This is only an isolated case.

4. Chlorides- Ranges between 36 mg/L and 900 mg/L. All the samples are well within the permissible limit of 1000 mg/L.

5. Cyanide- Not detected in any of the samples.

6. Lead- In 19 bore wells lead concentrations were observed which varied between 0.01 mg/L and 0.8 mg/L. In 10 samples lead is exceeding the permissible limit of 0.05 mg/L. In other bore wells it is below the detection levels.

7. Copper- In 15 bore wells copper concentrations is observed from 0.01 mg/L to 0.88 mg/L In rest of bore wells it is below the detection levels. Thus, all the samples are well within the permissible limit of 1.5 mg/L.

8. Hexavalent chromium- In 30 bore wells hexavalent chromium is not detected, in 41 samples it was below detention level. In 13 bore well the hexavalent chromium ranges from 0.05 mg/L to 32.5 mg/L. Most of the sample in which chromium is detected 12 out 13, are exceeding the limit of 0.05 mg/L. Hexavalent chromium is higher in 11 samples.

9. Zinc- In 54 bore wells Zinc concentrations were observed. It ranges between 0.01 mg/L and 1.85 mg/L. In other bore wells it is below the detection levels. Thus, all the samples are well below the permissible limit of 15mg/L.
10. Manganese- It ranged between 0.03 mg/L and 3.38 mg/L Four samples are exceeding the permissible limit of 0.3 mg/L.
11. Iron- In 66 bore wells iron concentrations were observed. In other bore wells it is below the detection levels. Min. and max. concentrations observed are 0.01 mg/L and 0.55 mg/L respectively. All the samples are within the permissible limit of 1 mg/L.
12. Cadmium- Concentration of cadmium was observed to be below the detection limits.
13. Nitrate as $NO_3$- 79 bore wells indicates the presence of nitrates, it ranges between 1.9 mg/L and 200 mg/L. 22 samples are exceeding the permissible limit of 45 mg/L.
14. Phenolic compounds- Not detected in any of the samples.
15. Hardness- It ranged between 169 mg/L and 1192 mg/L. 32 samples are exceeding the permissible limit of 600 mg/L though 10 samples are exceeding marginally.
16. Calcium as Ca- Ranges from 11 mg/L to 279 mg/L. All the 6 samples are exceeding the permissible limit of 200 mg/L marginally.
17. Magnesium as Mg- Ranges from 25 mg/L and 188 mg/L. Twelve samples are exceeding the permissible limit of 100 mg/L.
18. Fluoride- Fluoride Is found in 10 bore wells ranging from 0.1 mg/L and 1.5 mg/L. None of the samples indicated Fluoride concentration exceeding the permissible limit of 1.5mg/L.
19. Turbidity- No turbidity is represented in 58 bore wells; it ranges between 1 NTU and 16 NTU respectively. 7 samples are exceeding the limits marginally.
20. Alkalinity- Ranges between 130 mg/L and 461 mg/L. All are within the limits of 600 mg/L.

### *B. Parameters of Contamination for Different Bore wells*

1. 24 bore well water samples indicate that the water conform to the drinking water standards.
2. Out of 59 bore well exceeding the permissible limits, 37 bore wells are having a single parameter exceeding the limits. While, hardness being single parameter exceeding in 17 bore wells, followed by nitrates in 6, Lead in 10, hexavalent chrome in 13 and turbidity in 7 .
3. 9 bore wells have combination of nitrate and hardness as exceeding limits.
4. Fluoride and Iron which are considered as important parameters for drinking water, is well within the limits.
5. Highly toxic elements, Cyanide and phenolic compounds were not observed in underground water.
6. Among the heavy metals only Hexavalent chromium and lead are exceeding permissible limits.

### *C. Possible Source of Contamination and Quality of Ground Water*

It is generally observed that there is no uniform contamination of ground water with respect to specific parameter in the entire study area. As such presently there is no potential threat to the entire ground water, indicating that there are only a few pockets of contaminated ground water and these pockets are contaminated with respect to different types of contaminants. The sources of contamination are from different point sources and thus should be handled independently. Hence remedial approaches should be specific to the pocket and to the contaminant.

## V. REMEDIAL APPROACHES

Hardness is the single parameter exceeding the limits in 17 bore wells. Nitrate alone is exceeding permissible limit in 6 bore wells. While in 9 bore wells both hardness and nitrates are exceeding. By initiating remedial measures along with 24 non contaminated bore well, 67 % of locations in ground water can be made suitable for human consumption. The study area and its surrounding area lacks scientific sewage disposal facility, by addressing this issue, the contamination can further be prevented.

Hexavalent Chromium and lead are the only two toxic elements found in excess of permissible limits. This may due to improper historical disposal and/or industrial operations in the area. This problem is however only localized and can be handled by adopting suitable mitigative measures.

## VI. CONCLUSIONS

Based on the study on ground water analysis, the following conclusions are drawn***:***

1. Various parameters exceeding drinking water criteria in different bore wells are isolated, indicating that the contamination is only localized.
2. The parameters exceeding limits are found to vary in concentration in the bore wells.
3. Two general parameters exceeding limit, hardness and nitrate, can be controlled by adopting proper sewage treatment and disposal mechanism.
4. Toxic element, lead, is found in isolated stretches, which can be controlled by exercising industrial controls around these industries.
5. Only hexavalent chromium is found in a few stretches which can be redressed by initiating remedial measures, wherever it is found.

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