# SHALLOW GROUNDWATER QUALITY OF LAHORE CITY ALONG THE RIVER RAVI

By

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## ABSTRACT

The present study was conducted along the River Ravi to evaluate the shallow groundwater quality of Lahore City aquifer by assessing physical (color, odor and turbidity), chemical (pH, TDS, Cl, F, $NO_3$, Cu, Zn, Ni and Pb) and bacteriological (E. coli) parameters of fifteen shallow groundwater samples. The samples were collected during November 2009 to March 2010 with a 2 – month interval from five sites along the River Ravi which include Ravi Syphon (50 feet depth), Shahdarah Bridge (70 feet depth), Mohlanwal village (45 feet depth), confluence point of Hudiara and Sattukatla drains (80 feet depth) and Board of Revenue (BOR) Building (150 feet depth). It was observed that the color of shallow groundwater samples varied from colorless to yellowish, odor varied from odorless to objectionable (OB) and turbidity varied from 2 to 4 NTU. The pH, TDS, Cl, F, $NO_3$, Cu, Zn, Ni and Pb levels ranged from 7.4 to 7.9, 225 to 1098 ppm, 22.1 to 172.2 ppm, 0.16 to 0.61 ppm, 0.5 to 27.7 ppm, Below Detection Level (BDL) to 0.09 ppm, 0.07 to 0.19 ppm, BDL to 0.06 ppm, BDL to 0.11 ppm, respectively. E. coli were present in all shallow groundwater samples except at BOR Building. The turbidity, pH, TDS (except at confluence point of drains), $NO_3$, Cl, F, Cu and Zn levels were found within the permissible limits of WHO, US-EPA and Pak-EPA for drinking water quality. The Pb, Ni (except at Ravi Syphon and BOR Building) and E. coli (except at BOR Building) levels exceeded the permissible limits set for drinking water quality by WHO, US-EPA and Pak-EPA. The study also recommended various measures and practices for control and mitigation of shallow groundwater contamination.

**KEY WORDS:** Shallow groundwater quality, Lahore City aquifer, WHO, US-EPA, Pak-EPA, drinking water, permissible limits, control, mitigation, shallow groundwater contamination.

## INTRODUCTION

Groundwater being a significant nonrenewable resource on the earth is a primary source of drinking water in the world [1]. Groundwater is not only used for domestic purposes but is also used for irrigation, industries and municipalities [2]. The groundwater gets contaminated naturally (such as weathering of rocks and soil) and by anthropogenic activities (such as waste disposal practices, storage and transport of commercial materials, mining operations and agricultural activities). The chances of contamination from natural sources are less as compared to anthropogenic sources [3].

In Pakistan, most of the groundwater resources occur in Indus Plain which extends from the Himalaya foothills to the Arabian Sea. The water is stored in the alluvial deposits under unconfined conditions covering about 21 Mha [4]. The Pakistan groundwater resource is divided into five zones: i.e. (i) sweet groundwater areas; (ii) areas where canal or river water is a real alternative; (iii) mountainous and hilly areas where spring water is available; (iv) the eastern desert belt where groundwater is available at increasing depth; and, (v) coastal areas where the groundwater is saline [5]. In Punjab Province, the fresh groundwater is available in about 79% area while the highly saline water is present in south and desert areas [6 &7]. The disposal of untreated municipal and industrial effluents and agricultural wastes into surface water bodies contaminates both the surface water and groundwater. In Punjab, River Ravi gets contaminated due to the disposal of huge quantities of pollution from municipal, industrial and agricultural activities which in turn deteriorates the quality of groundwater [8 & 5]. The present study was carried out to evaluate the shallow groundwater quality of Lahore City aquifer lying in close vicinity of River Ravi for drinking purpose.

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1. Internee at Irrigation Department, Lahore

## MATERIALS AND METHODS

A total of fifteen shallow groundwater samples were collected from hand pumps and motor pump at five sites including Ravi Syphon, Shahdarah Bridge, Mohlanwal village, confluence point of Hudiara and Sattukatla drains and Board of Revenue (BOR) Building as shown in Figure 1 at depths of 50, 70, 45, 80, and 150 feet, respectively.

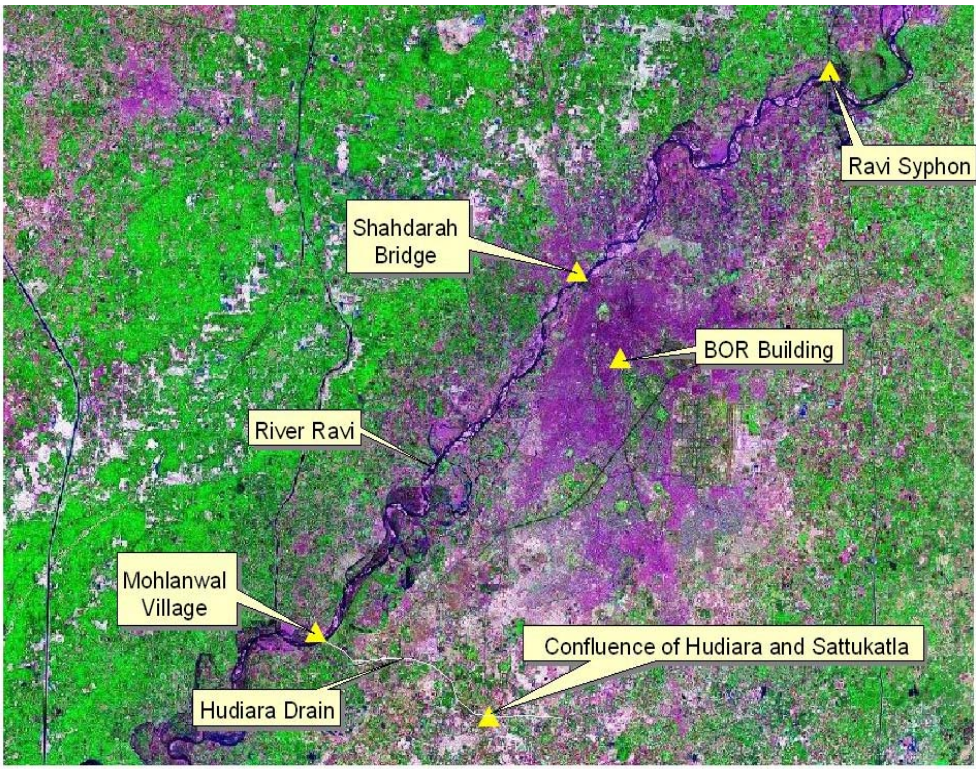


Figure-1. Map showing location of study sites

The samples were taken from November 2009 to March 2010 after every 2- month interval. The collection and preservation of samples was done according to standard methods prescribed by Greenberge *et. al*, 1992 [9]. The physical (color, odor and turbidity), chemical (pH, TDS, Cl, F, $NO_3$, Cu, Zn, Ni & Pb) and bacteriological (Escherichia coli) parameters were evaluated. Color and odor were measured by sensory tests or general observations, TDS were determined by multiplying the electrical conductivity (EC in dS/m) values with 640 and E. coli were measured by Bacti kit. The other parameters were analyzed according to standard methods prescribed by Greenberge *et. al*,1992 [9]. The values of physical, chemical and bacteriological parameters were compared with WHO, US-EPA and Pak-EPA drinking water quality criteria to determine the drinking water quality status of shallow groundwater samples (Table-1).

Table-1. Drinking Water Quality criteria

| | TDS (ppm) | Cl (ppm) | Fl (ppm) | $NO_3$ (ppm) | Cu (ppm) | Zn (ppm) | Ni (ppm) | Pb (ppm) | E. coli |
|---|---|---|---|---|---|---|---|---|---|
| WHO Criteria | <1000 | 250 | 1.5 | 50 | 2 | 3 | 0.02 | 0.01 | 0 in 100ml |
| Pak-EPA Criteria | <1000 | < 250 | ≤1.5 | ≤ 50 | 2 | 5 | ≤0.02 | ≤0.05 | 0 in 100ml |
| US-EPA Criteria | 1000 | 250 | 2 | 10 | 1 | 5 | - | 0.015 | - |

## RESULTS AND DISCUSSION

### Physical Parameters Evaluation

*Color and Odor:* The color of water samples varied from colorless to yellowish while the odor of water samples varied from odorless to objectionable (Table-2). The presence of color and odor in the shallow groundwater indicates the leaching of agricultural wastes, domestic sewage and industrial effluents through surface water to the shallow groundwater.

Table-2. Color and odor analysis of water samples

| Sr. # | Study Site | Color | Odor |
|---|---|---|---|
| 1 | Ravi Syphon | Colorless | Odorless |
| 2 | Shahdarah Bridge | Yellowish | Odorless |
| 3 | Mohlanwal Village | Yellowish | OB |
| 4 | Confluence point of Hudiara and Sattukatla drain | Yellowish | Odorless |
| 5 | BOR Building | Colorless | Odorless |

*Turbidity*: The turbidity levels in shallow groundwater samples ranged from 2 to 4 NTU (Figure- 2) with the minimum level at Ravi Syphon and the highest level at confluence point of Hudiara and Sattukatla drains. The turbidity level of shallow groundwater samples was within the permissible limits for drinking water quality (turbidity < 5 NTU).

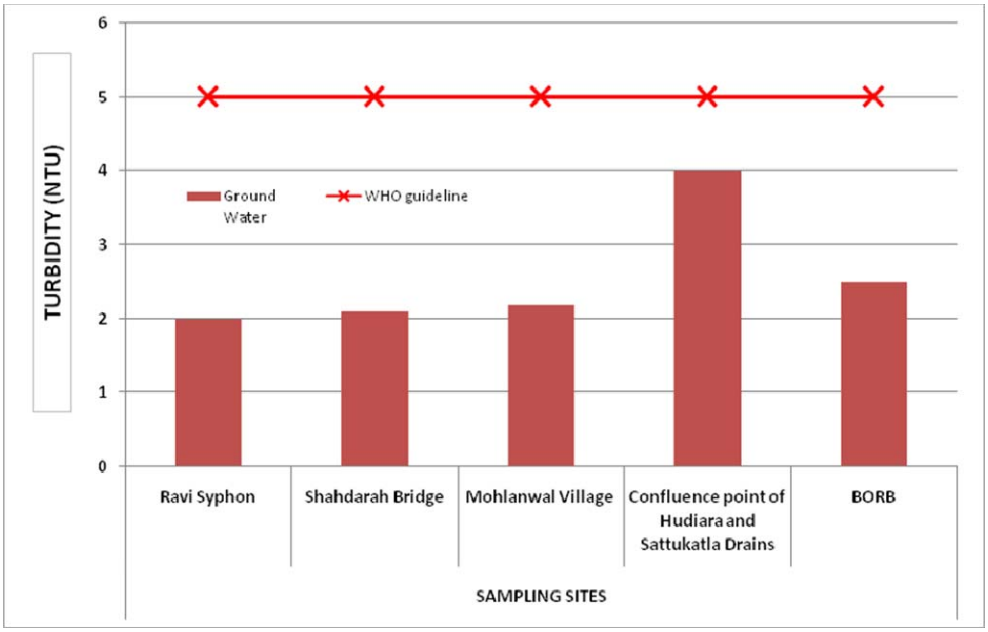


Figure-2. Turbidity levels of water samples

### Chemical Parameters Evaluation

*pH*: pH levels in the shallow groundwater samples ranged from 7.4 to 7.9 (Figure-3) with the minimum value at Ravi Syphon and Shahdarah Bridge while the maximum value was noted at confluence point of drains. In the year 2007, pH level in the groundwater of Shahdarah Bridge was 7.7 [8] which showed a slight decrease in the present study i.e. 7.4. The pH levels at all the sampling sites were within the permissible limit for drinking water quality (pH: 6.5 – 8.5).

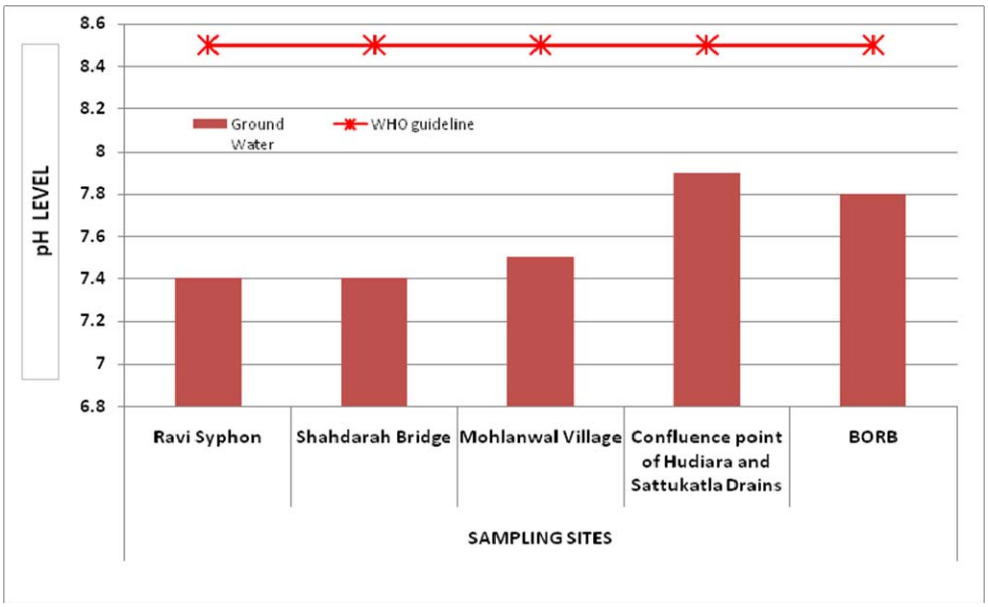


Figure-3. pH levels of water samples

*Total Dissolved Solids (TDS):* The TDS levels in the shallow groundwater samples ranged from 225 to 1098 ppm (Figure-4) with the minimum value at Ravi Syphon and maximum value at confluence point of drains.

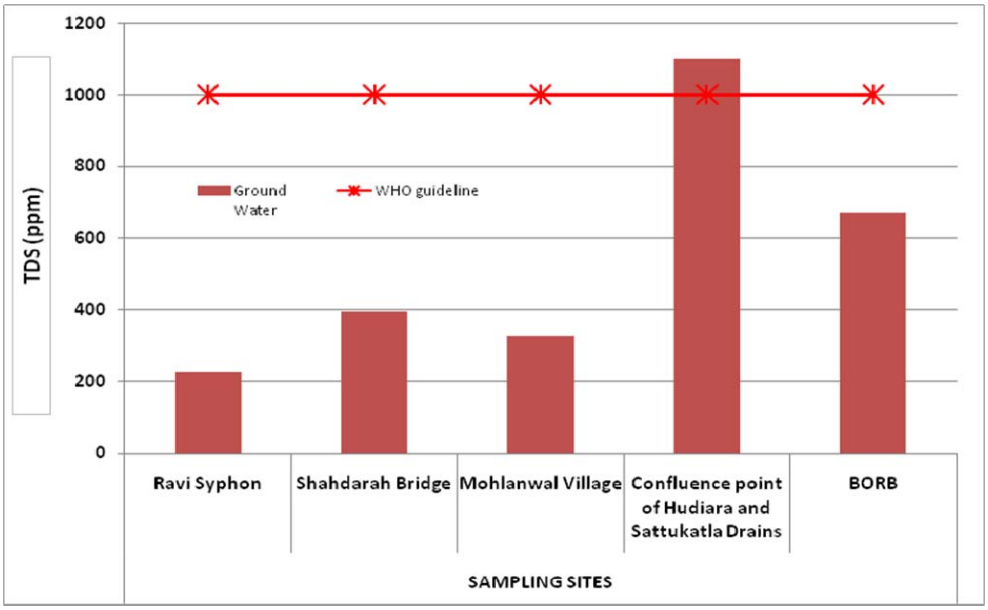


Figure-4. TDS values of water samples

In the year 2007, the TDS level in groundwater at Shahdarah Bridge was 191 ppm [8] which increased in the present study and reached at 395 ppm. TDS level in all water samples (except at confluence point of drains) were within the permissible limits for drinking water quality (Table- 1).

*Chloride (Cl):* The chloride concentration in the shallow groundwater ranged from 22.1 to 172.2 ppm (Figure-5) with the minimum value at Ravi Syphon and maximum value at confluence point of drains. The chloride levels at all sampling sites were within the permissible limits set for drinking water quality (Table-1).

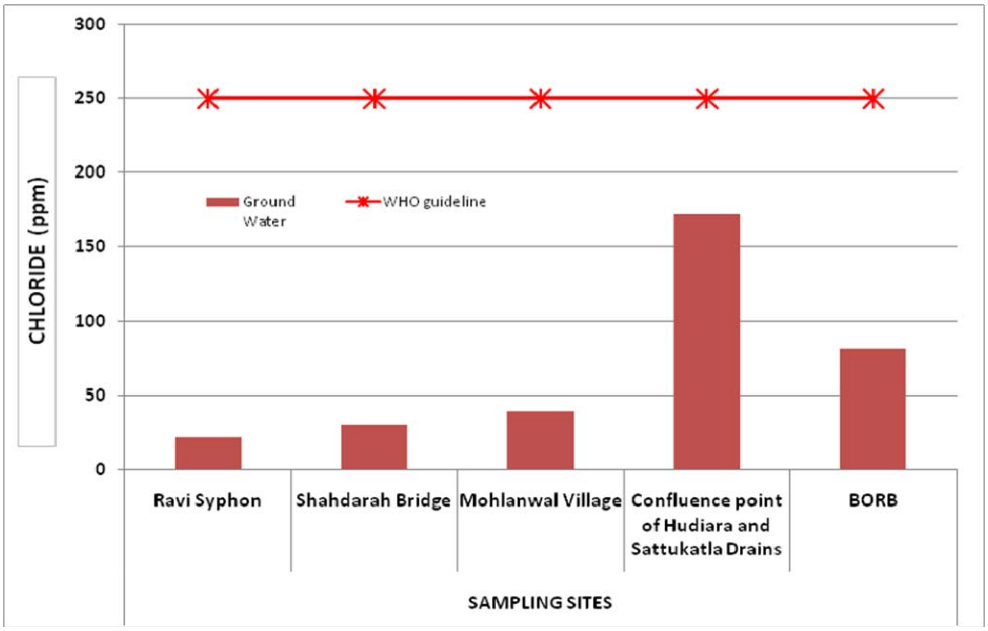


Figure-5. Chloride levels of water samples

*Fluoride (F):* The fluoride level in the shallow groundwater samples ranged from 0.16 to 0.61 ppm (Figure-6) with the minimum value at Ravi Syphon and maximum value at confluence point of drains. The fluoride levels at all sampling sites were within the permissible limits for drinking water quality (Table-1).

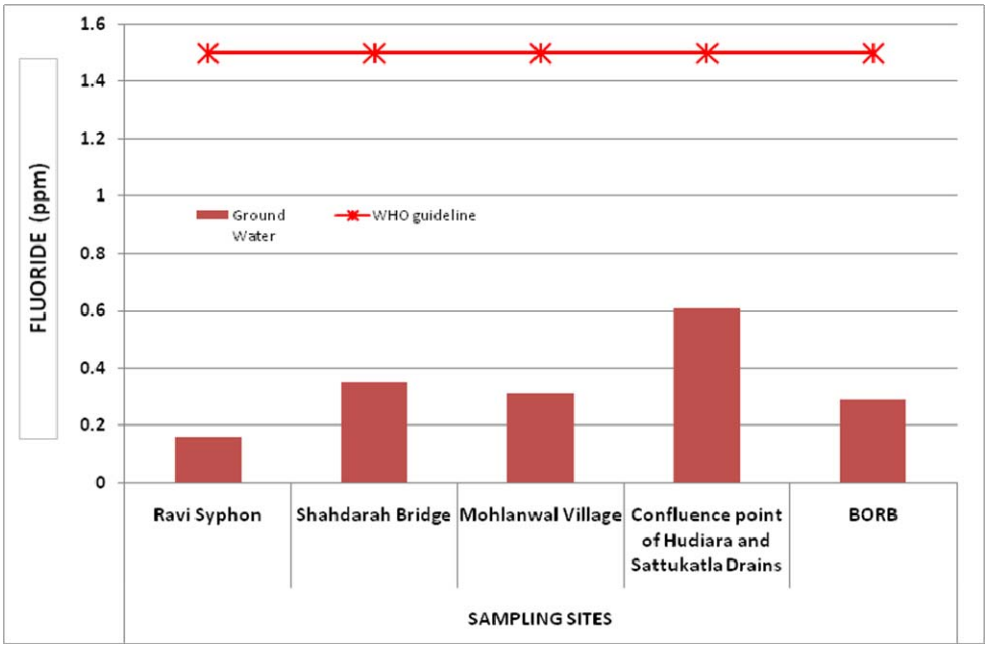


Figure-6. Fluoride levels of water samples

*Nitrate ($NO_3$):* The nitrate concentrations in the shallow groundwater samples ranged from 0.5 to 27.7 ppm (Figure-7) with the minimum value at Ravi Syphon and maximum value at confluence point of drains. In the year 2007, nitrate level in the groundwater at Shahdarah Bridge was 0.3 ppm [8] which increased in the present study (2.9 ppm). The nitrate levels at all sampling sites were within the permissible limits set by WHO, Pak-EPA and US-EPA (except for water at confluence point where it was high for standards set by US-EPA) for drinking water (Table-1).

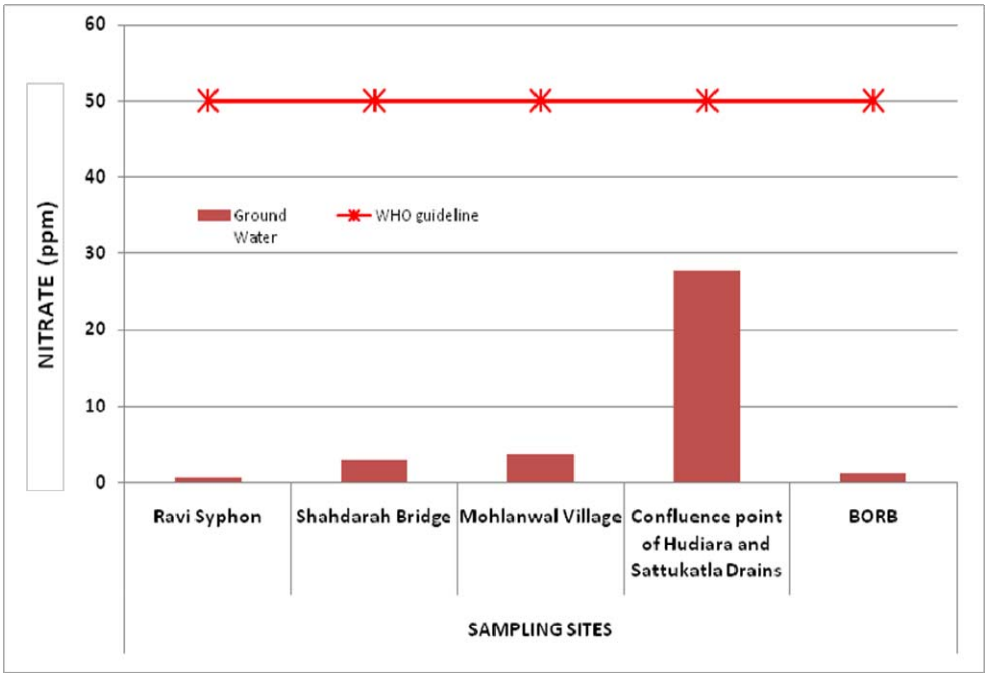


Figure-7. Nitrate levels of water samples

*Copper (Cu):* The copper level in the shallow groundwater samples ranged from Below Detection Level (BDL) to 0.09 ppm (Figure-8) with the minimum copper level at BOR Building and the maximum value at Shahdarah Bridge and confluence point of drains. The copper levels at all sampling sites were within the permissible limits for drinking water quality (Table-1).

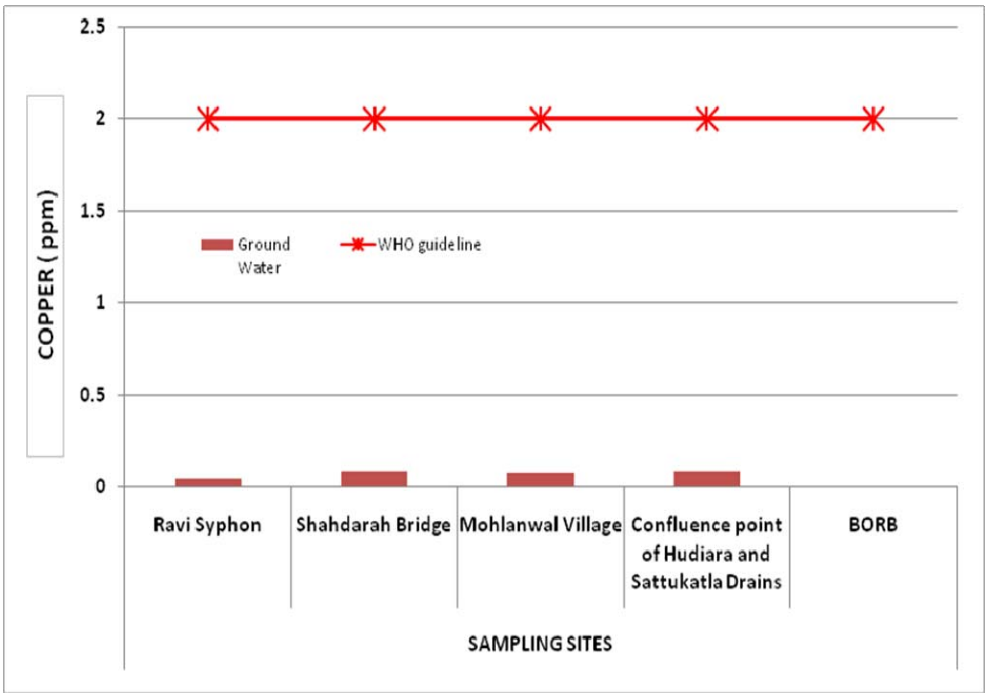


Figure-8. Copper concentrations of water samples

*Zinc (Zn):* The zinc concentrations in the shallow groundwater samples ranged from 0.07 to 0.19 ppm (Figure-9) with the minimum value at Ravi Syphon and maximum value at confluence point of drains. The zinc levels at all sampling sites were within the permissible limits for drinking water quality (Table-1).

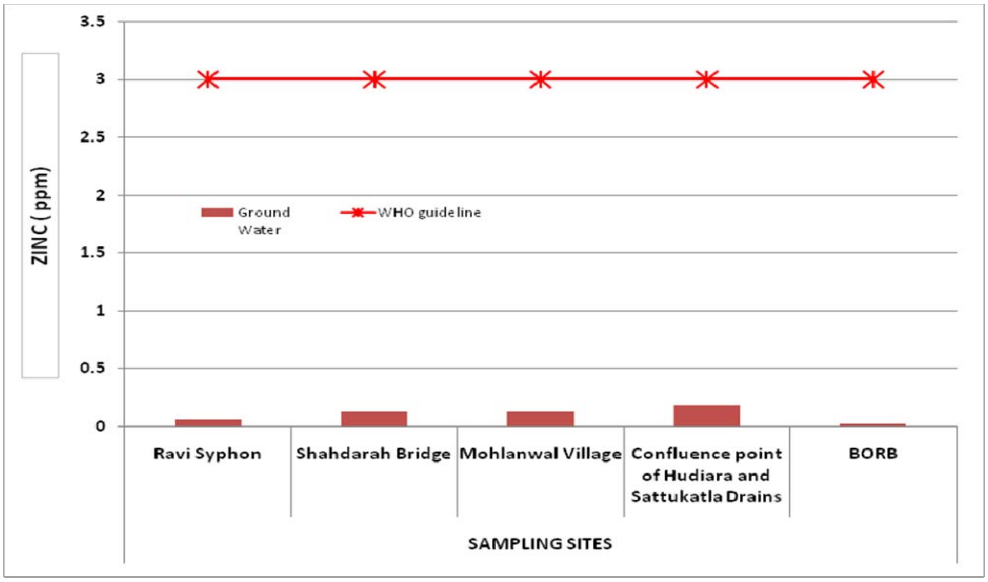


Figure-9. Zinc concentrations of water samples

*Nickel (Ni):* The nickel level in the shallow groundwater samples ranged from BDL to 0.06 ppm (Figure-10) with the minimum level at Ravi Syphon and BOR Building. The maximum nickel levels were noted at Mohlanwal village and confluence point of drains. In the shallow groundwater samples the nickel levels were exceeding the permissible limits for drinking water quality (Table-1) at all sampling sites except at Ravi Syphon and BOR Building. The presence of nickel in water samples indicated the contamination of shallow groundwater with industrial effluent generated from oil and ghee industries, electroplating workshops and dyeing units.

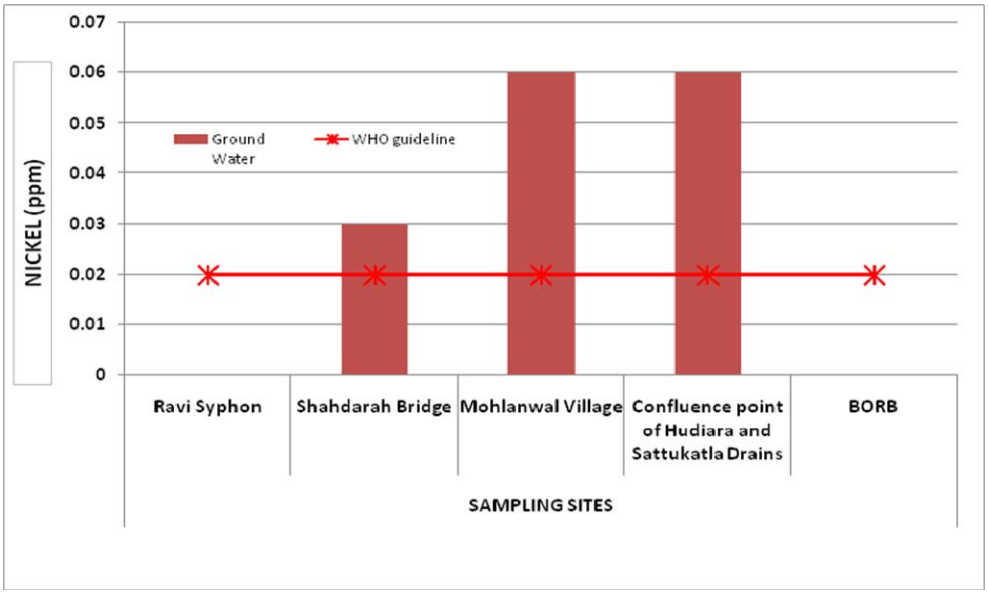


Figure-10. Nickel levels of water samples

*Lead (Pb):* The lead level in the shallow groundwater samples ranged from BDL to 0.11 ppm (Figure-11). The minimum lead levels were found at Ravi Syphon and BOR Building while the maximum lead level was noted at confluence point of drains. The lead levels in the shallow groundwater were exceeding the permissible limits for drinking water quality (Table-1) at all sampling sites except at Ravi Syphon and BOR Building. The presence of lead in water samples indicated the contamination of shallow groundwater with industrial effluent generated from batteries manufacturing units and paint and coating industries.

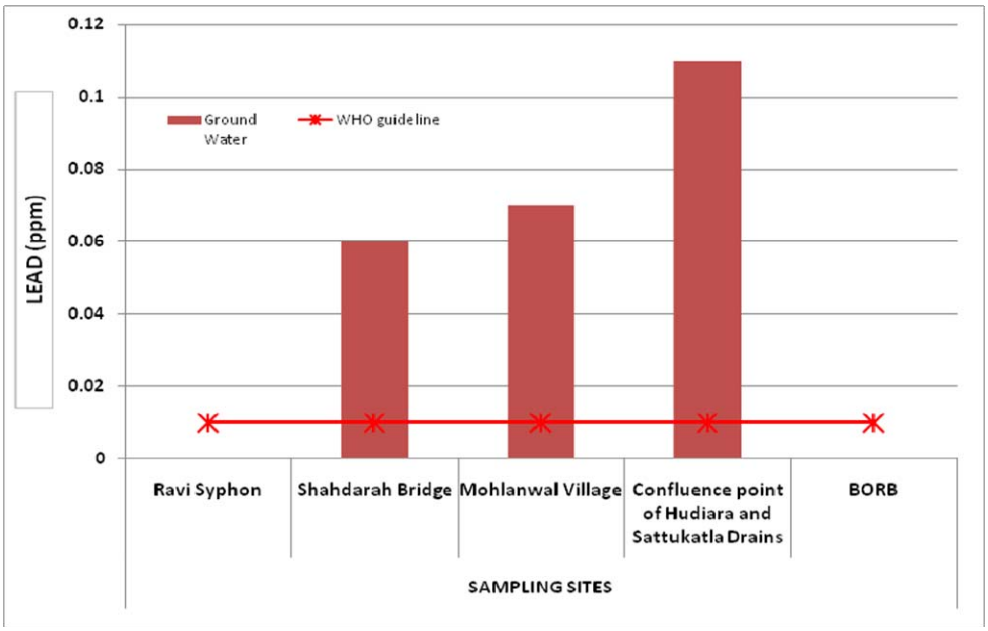


Figure-11. Lead levels of water samples

**Bacteriological Parameters Evaluation**

*E. coli:* E. coli were present in all shallow groundwater samples except at BOR Building. The presence of E. coli in water samples indicated the contamination of shallow groundwater source due to disposal of agricultural, domestic and animal wastes into surface water of River Ravi. The E. coli levels at all sites except at BOR Building were exceeding the permissible limits for drinking water quality (Table-1).

## CONCLUSIONS AND RECOMMENDATIONS

The conclusions derived from the present study include:

- The color of water samples varied from colorless to yellowish, odor varied from odorless to OB and turbidity varied from 2 to 4 NTU.

- The pH, TDS, Cl, F, $NO_3$, Cu, Zn, Ni and Pb levels of shallow groundwater samples ranged from 7.4 to 7.9, 225 to 1098 ppm, 22.1 to 172.2 ppm, 0.16 to 0.61 ppm, 0.5 to 27.7 ppm, BDL to 0.09 ppm, 0.07 to 0.19 ppm, BDL to 0.06 ppm, BDL to 0.11 ppm, respectively.

- E. coli were present in all shallow groundwater samples except at BOR Building.

- Turbidity, pH, TDS (except at confluence point of drains), $NO_3$, Cl, F, Cu and Zn levels of water samples were found within the permissible limits of WHO, US-EPA and Pak-EPA for drinking water quality. The Pb, Ni (except at Ravi Syphon and BOR) building and E. coli (except at BOR) building levels exceeded the permissible limits of drinking water quality.

- The shallow groundwater at some sites showed the presence of color and odor. The yellowish color was observed in the shallow groundwater at Shahdarah Bridge, while both yellowish color and odor was found at Mohlanwal village.

- The shallow groundwater was found contaminated with lead and nickel. Lead was found at Shahdarah Bridge and Mohlanwal village. The nickel was found at Mohlanwal village and confluence point of Hudiara and Sattukatla drains. The concentrations of both metals (Pb & Ni) were exceeding the WHO, US-EPA and Pak-EPA permissible limits for drinking water quality.

## Recommendations

The recommendations emerged from the present study include:

- The groundwater quality needs to be monitored regularly by following effective enforcement of water quality laws and regulations.

- Nickel and lead filters may be installed where groundwater is used for drinking purposes.

- An effective public awareness raising campaign needs to be launched in the study area to create sensitivity among groundwater users about bad quality of groundwater, adverse impacts of its use on human health and adoption of measures, practices and technologies to improve drinking water quality.

- The implications of contaminated groundwater on human health need to be investigated through comprehensive studies.

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