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# Urban impacts on groundwater quality in the Delhi region

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**Abstract** In recent years, water supply and groundwater resources in India have become threatened following uncontrolled disposal of urban waste into water bodies, open waste dumping and poorly designed landfills. Within the urban fringe zones of Delhi, the contamination of groundwater by industrial and domestic effluents now presents serious challenges. Subsoil waters in the area through which effluents from major industries infiltrate, are already polluted more or less permanently. Wells in many residential areas are contaminated with nitrate, detergents and high salinity levels with the high content of fluoride also posing severe health hazards in surrounding regions.

## INTRODUCTION

Groundwater pollution has emerged as an important environmental issue all over the world with life support systems increasingly threatened by both anthropogenic activity and waste mismanagement. In India, contamination sources include industrial and domestic effluents, wastes sites, storage and transport of hazardous substances etc., as well as fertilizers, herbicides and pesticides from agricultural usage. Urban air pollution also contributes by acid precipitation. Groundwater systems are not only highly sensitive to land and water pollution in areas of groundwater recharge but also to changes in flow condition. In recent times, severe arsenic pollution of drinking water sources in India has attracted attention due to health effects in terms of skin disease. The management of such issues requires an integrated approach and public policies that support planning for the use and sustainable management of land and water resources. There is also a need to develop close linkages between economic forces, land use and landscape effects (Hilding-Rydevik & Johansson, 1997).

## THE STUDY AREA: THE DELHI METROPOLITAN REGION

Geographically Delhi is situated along the western and eastern banks of the Yamuna River. Its altitude is 220 m above mean sea level with the difference between maximum and minimum levels being about 60 m. The territory is divided into five administrative blocks, viz. Alipur, Kanjhawala, Najafgarh, Shahdara and Mehrauli although recently another city block has been created. In the present study, two blocks (Alipur and Kanjhawala) have been selected for detailed empirical study.

## ENVIRONMENTAL IMPACT OF URBAN AND INDUSTRIAL DEVELOPMENT

Delhi, which is the Indian capital city, ranks third in population among Indian cities and thirteenth among cities of the world. The growth of Delhi had only been slow and gradual until India's independence in 1947 but considerably intensified after this date. From a small number of about 8000 industrial establishments in 1950–1951, the number had increased to over 90 000 by 1995. Government policies helped this rapid industrial growth by providing facilities and incentives. However, this has resulted in a mixed and even conflicting land use as well as causing a deterioration in the quality of land and water.

The prime cause of critical unsanitary conditions in many cities in India is due to the lack of facilities for collection and disposal of wastewater. Data on wastewater generation and collection is poor in comparison to information on water supply and therefore it is difficult to access the total pollution potential. Municipalities dispose of their treated, partly treated or untreated wastewater into natural surface water drains, or it is applied directly to land for irrigation or in some cases recharged to groundwater. The city of Delhi is only partially sewered but even in the sewered areas not all sources of wastewater (including households) are connected to the sewerage system. Table 1 provides pollutant-loading data for the three Delhi wastewater treatment plants in terms of industrial and domestic effluents (Central Pollution Control Board, 1995).

Out of the total pollution loads generated from domestic wastewater, only a part is discharged to the wastewater treatment plants with the remaining fractions finding

**Table 1** Relative contribution of pollution loads.

| Item | Discharge (KLD) | Parameters of pollution: BOD (kg day$^{-1}$) | TDS (kg day$^{-1}$) | TSS (kg day$^{-1}$) |
|---|---|---|---|---|
| **Najafgarh** | | | | |
| Domestic wastewater | 270 000 | 72 500 | 145 000 | 72 500 |
| Industrial wastewater | 18 100 | 5500 | 19 800 | 6800 |
| Total | 5500 | 78 000 | 164 800 | 79 300 |
| Industrial % | 6.3 | 7.1 | 12.0 | 8.6 |
| **Trans-Yammuna MCD** | | | | |
| Domestic wastewater | 32 000 | 5225 | 10 450 | 5225 |
| Industrial wastewater | 4300 | 1500 | 1000 | 1500 |
| Total | 36 300 | 6725 | 11 450 | 6725 |
| Industrial % | 11.8 | 22.3 | 8.7 | 22.3 |
| **Kalkaji** | | | | |
| Domestic wastewater | 9000 | 2800 | 5600 | 2800 |
| Industrial wastewater | 400 | 400 | 300 | 400 |
| Total | 9400 | 3200 | 5900 | 3200 |
| Industrial % | 4.2 | 4.8 | 6.7 | 4.8 |
| **All drains combined** | | | | |
| Domestic wastewater | 514 560 | 147 300 | 294 600 | 47 300 |
| Industrial wastewater | 22 800 | 7400 | 21 100 | 8700 |
| Total | 537 360 | 154 700 | 315 700 | 156 000 |
| Industrial % | 4.2 | 4.8 | 6.7 | 5.6 |

Source: Based on Central Pollution Control Board (1979, 1995).

their way, directly or indirectly (through seepage and overflow etc.) into the river Yamuna via various open drains. However, having no better basis for the assessment of domestic wastewater and pollution loads reaching various drains, it has been conservatively assumed that roughly 50% of the wastewater and pollution load is carried by sewers with the remainder flowing to open drains. Such flows cause severe problems in terms of groundwater pollution.

## GROUNDWATER QUALITY

In the Alipur block, out of 21 monitoring stations only five stations viz. Wazirabad, Bakhtawarpur, Holambikan, Jindpur and Hiranki, show comparatively high salinity. A high value of residual sodium carbonate (RSC) in irrigation water causes increases in sodium adsorption with values greater than 5 meq $l^{-1}$ having detrimental effects on crop growth. The levels of nitrate in all the groundwater samples are within the permissible limit set for drinking water purposes. The Kanjhawala block shows comparatively more salinity i.e. >4000 μmhos $cm^{-1}$ at Chandpur, Nithari and Tikri Kalan. At all other stations, groundwaters have either low or marginal salinity. The RSC values in some places such as Mundka, Bawana and Qutabgarh are more than 5 meq $l^{-1}$ indicating that these areas are affected by sodium hazard (Central Board for the Prevention and Control of Water Pollution, 1985). As in the case of the Alipur block, the predominant cation in Kanjhawala is also sodium whereas a considerable number of stations contain chloride as the dominant anion. Tables 2 and 3 summarize data for four of the Delhi administrative blocks in terms of salinity, nutrient and heavy metal loads.

## STATUS OF HEAVY METALS IN GROUNDWATER

The trace elements surveyed at all monitoring stations are lead, zinc, copper, nickel and cadmium. Other metals, except lead in a few well waters, were within the

**Table 2** Maximum permissible limits and observed values of parameters in the groundwater of Alipur and Kanjhawala Blocks of Delhi.

| Parameters | Maximum. limits for drinking water (μg $l^{-1}$) | Frequency distribution of actual observed values: No. of samples out of 42: Alipur Block | Kankhawala Block | Concentration (μg $l^{-1}$): Alipur Block | Kankhawala Block |
|---|---|---|---|---|---|
| Cadmium | 10 | 21 | 17 | 0–5 | 0–6 |
| | | | 4 | - | 11–25 |
| Lead | 100 | 18 | 18 | 0–58 | 0–96 |
| | | 3 | 3 | 142–428 | 102–204 |
| Chromium | 50 | 20 | 21 | 0–34 | 0–27 |
| | | 1 | | 50 | - |
| Zinc | 15 000 | 21 | 21 | 0–43 | 0–78 |
| Copper | 1500 | 21 | 21 | 0–38 | 0–31 |

Source: Central Board for the Prevention and Control of Water Pollution (1985).

**Table 3** Areas having poor quality and polluted groundwater.

| Block | Salinity | Nitrate | Fluoride | Heavy metals |
|---|---|---|---|---|
| Kanjhawala | Entire block saline | No serious problems except around a few villages | Around Sultanpuri, Nangloi, Kanjhawala and Mundka | Mainly western part, to 40 m depth (lead) |
| Najafgarh | Entire block saline except the drain and southwestern part | Present along with high fluoride in southwest part | Except control part, whole block is polluted | Mainly cadmium in central and western part, lead in southeast part |
| Shahdra | No serious problem | No serious problem | No serious problem | Highly polluted by lead and cadmium; chromium to 40 m depth |

Source: Based on Central Groundwater Board (1998) and Central Pollution Control Board (1998).

permissible levels for drinking water (Table 2). Data revealed that out of 30 locations in the Alipur and Kanjhawala blocks, three locations in Alipur and two locations in the Kanjhawala block were contaminated, with cadmium exceeding the drinking water standard by 17 and 11 $\mu g\ l^{-1}$ respectively in the latter location. Out of 42 wells in both blocks, the survey revealed that the level of lead in six wells, (three in each block), exceeded the drinking water standard (see Table 2).

In terms of irrigation water quality the heavy metal concentration in all the ground water stations of Alipur and Kanjhawala block were within the permissible limit particularly with respect to locations having fine textured soils. Among anions, nitrate shows the highest measure of variability in both the blocks. The values of nitrate never exceeded the permissible limit (50 mg $l^{-1}$ as $NO_3$) with concentrations of trace metals being well within the limit of the drinking water standard. On the basis of detailed analysis of groundwater quality, the Central Ground Water Board (1998) of New Delhi recently informed the public that groundwater from shallow water-bearing zones up to 30 m deep has high concentrations of fluoride and nitrate and was not fit for drinking purposes. It advised that groundwater within certain areas should not be used for drinking purposes without proper treatment.

## GROUNDWATER MANAGEMENT

Groundwater recharge projects should be initiated for augmenting available supplies with abstractions regulated to ensure they do not exceed recharge possibilities. Integrated development of surface water and groundwater and their rational usage must be encouraged right from the project planning stage and should form an essential part of a phased water resource development programme. There is a need for water zoning and constraints on water usage in the metropolitan region and the economic activities should be regulated in accordance with such zoning (Government of India, 1987). Serious consideration needs to be given to storage and recharge of rainfall-runoff in low lying areas and to recharge of aquifers by treated wastewater. In addition, environmental improvement along roads and majors drains is needed (Asian Development Bank, 1993). There is also promising scope for the use of remote sensing techniques for pollution detection and detailed, continuous monitoring of both surface and groundwaters.

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