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Case Study on Assessment of Ground Water Quality at Ludhiana

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ABSTRACT: The studies were undertaken for the Assessment of Ground Water Quality of Ludhiana metrocity (Punjab). The ground water flow in the city is from North to South. There is no source of surface water in the study area (Ludhiana). All the requirement of water is met by the ground water available in the area. The ground water is mostly used for drinking purposes as well as for industrial, irrigation and other uses in the region.

The present case study was carried out for Ludhiana metro city for assessment of ground water quality with the objectives to assess its ground water quality during pre and post monsoon periods located at locations a Industrial zone; b. Municipal solid waste dumping site and c. Residential zone. A total of 25 numbers samples for each seasons were collected. These were for Physical, Chemical and Biological constituents for the pre monsoon and post monsoon season. All the results were evaluated with respect to BIS Standard on Drinking Water IS 10500 and World Health Organisation.

The pH at all the locations is almost neutral ranging between 7.4–7.5 which is well within the standard limit indicating thereby that the water in this area is suitable for drinking. The Total Dissolved Solids (TDS) are ranging between 416 to 452 mg/L and the Conductivity ranges between 690 to 774 μmhos/cm, which confirms the correlation between the two that the conductivity increases on increase of TDS. The values of Fluoride are ranging between 0.77 to 0.81 mg/L and Hardness between 216 to 232 mg/L which are within the specified limits at all the locations. The cations and anions are within limits at all the locations. The values of Alkalinity are ranging between 287 to 304 mg/L which is higher than the prescribed standard and could be mainly due geological conditions of location. The heavy metals in this area are not very high ranging between 0.01 to 0.08 mg/L. The total and fecal coliforms are also negligible ranging between < 2.0 MPN/100 mL at all the locations indicating thereby that there is no bacteriological contamination.

Results indicate that rapid urbanization and industrialization are major source of inorganic, organic and heavy metals in ground water. The quality of ground water from a few shallow tube wells has been impaired in some of the areas. However, the deep bore tube wells have not yet been affected.

INTRODUCTION

Ludhiana is one of the prime manufacturing and education center in northern India. It is known for hosiery, industry, dyes, bicycle and parts, mopeds, sewing machines and motor parts. Trading in these materials is also a source of employment and wealth generation in the city. The city has several educational institutions. The Agricultural University is well known for its contribution to agricultural revolution. While textile adds dynamism to the city, it also poses threat to environment. Industrial effluent management system needs attention. To successfully implement proposals envisaged towards waste water management would require Urban Local Body partnership with Industry department and private entrepreneurs. Alternate delivery and management options needs to be explore.

The population of the city has grown from 10.42 to 13.95 lakhs during 1991–2001 period recording 38% decadal growth rate. The growth rate had been very rapid (50% +) during the decades 1961–71, 1971–81 and 1981–91. Growth rates declined during previous decade. Assuming high rate of growth (of 48% and 59%) the city estimates the population to be 20.66 lakhs and 32.96 lakhs by 2001 and 2021 respectively. The estimate for 2005 is 16.65 lakhs people. Forecasts appears to be on the higher side.

PWSSB plans, design and executes the water supply project on behalf of MCL. MCL is responsible for operation and maintenance of water supply systems. The city of completely dependent on ground water. Depletion of water table is reported. (Water is extracted from deep tubewells at 400–450 feet depth and shallow wells at 180 feet). The per capita supply is 196 LPCD. Installed capacity is 415 MLD. With high population estimate (18 lakh population including floating population @220 LPCD the present gaps are

estimated to be in the order of 62 MLD. By 2011 additional 23 MLD additional demand has been estimated. As major source is ground water direct pumping is generally the practice followed to be distribute water.

Realizing the importance of groundwater quality in urban areas and its deterioration, CPCB initiated groundwater quality with the help of Pollution Control Research Institute (PCRI), BHEL, Haridwar.

As part of this Pollution Control Research Institute was undertaken Study on Assessment of Ground Water Study for LUDHIANA CITY during 2003 for the Summer and Post Monsoon period.

Land use activity along with potential threat to Groundwater is presented in Table 1.

Table 1: Land Use Activities and Their Potential Threat to Groundwater Quality at Ludhiana

Land Use	*Activities Potential to Groundwater Pollution*
Residential	• Un-sewered sanitation • Land and stream discharge of sewage • Sewage oxidation ponds • Sewer leakage, solid waste disposal, landfill leachate • Road and urban run-off, aerial fall out
Industrial and Commercial	• Process water, effluent lagoon etc. • Land and stream discharge of effluents • Tank and pipeline leakage and accidental spills. • Well disposal of effluent • Aerial fall out • Landfill disposal and solid wastes and Hazardous wastes • Poor housekeeping • Spillage and leakages during handling of material

METHODOLOGY

Study Area

Ludhiana city, the districts headquarter of Ludhiana district is one of the biggest city of Punjab. It lies between north latitude 30–34′ and 30′′01′ and east longitude 75–18′ and 76–20′. The depths of ground water level in Ludhiana city were—Static Water Level (55–60′), Shallow Tube wells (100–130′) and Deep (Submersible) Tube wells (200–300′).

Sampling

The samples were collected from:

- Drinking water wells;
- Wells closer to polluting sources like industries, urban wastewater drains, garbage dumpsites etc.;
- Wells suspected for natural contaminants like fluoride, iron, arsenic or such pollutants.

The standard method for Sample collection, transport, preservation and analysis of samples were followed as prescribed in "Stand Method of Water and Waster Examination (APHA, 2000).

The samples were analyzed immediately for the parameters like Coliform, BOD, COD and nutrients. Other parameters were analyzed within a week time.

Total twenty five ground water samples from different locations of city as given in Figure 1 were collected each during pre-monsoon (June 2003) and post-monsoon (December 2003) seasons from various abstraction sources at various depths covering extensively populated area, commercial, industrial, agricultural and residential colonies so as to obtain a good aerial and vertical representation and preserved by adding an appropriate reagents as and when required. The hand pumps were continuously pumped prior to the sampling, to ensure that ground water to be sampled was representative of ground water aquifer. The water samples for trace element analysis were collected in acid leached polyethylene bottles and preserved by adding ultra pure nitric acid (2 mL/lit.) Samples for pesticides analysis were collected in glass bottles while samples for bacteriological analyses were collected in sterilized high-density polypropylene/ Glass bottles covered with aluminum foils. All the samples were stored in sampling kits maintained at 4°C and brought to the laboratory for detailed chemical and bacteriological analysis. The standard methods (APHA, 20th Edition) adopted for each parametric analysis of groundwater samples.

The details of sampling locations and source and depth wise distribution in study area are given at each section city wise in the following chapter.

Comparison of Groundwater Samples with Indian Drinking Water Standards (BIS-IS 10500: 1991 and WHO Guideline, 1996) in Metropolitan Cities and Problem Areas

Water is a prime natural resource, a basic human need and precious natural asset. The provision of drinking water that is not only safe is a matter of high priority. The supply of water that is un-satisfactory in this respect will undermine the confidence of consumers leading to complaints and possibility of using water from less safe sources. Looking to the seriousness of groundwater contamination is now a great concern. Therefore, all the groundwater samples collected from drinking sources have been compared with present Indian standards in this report. The BIS–10500 and WHO Guideline has been presented in the form of Table 2 is given next page:

Table 2: Indian Standards and WHO Guideline for Drinking Water

S. No.	Parameter	BIS, Indian Standards (IS 10500:1991)		World Health Organization (WHO Guideline)
		Desirable Limit	Permissible Limit	Maximum Allowable Concentration
1.	Colour	5 Hazen Units	25 Hazen Units	15 True Colour Units
2.	Turbidity	5.0 NTU	10 NTU	5.0 NTU
3.	PH	6.5–8.5	No relaxation	6.5–8.5
4.	Total Hardness (as $CaCO_3$)	300 mg/L	600 mg/L	500 mg/L
5.	Chlorides (as Cl)	250 mg/L	1000 mg/L	250 mg/L
6.	Residual Free Chlorine (When	0.2 mg/L	–	–
7.	Dissolved Solids	500 mg/L	2000 mg/L	1000 mg/L
8.	Calcium (as Ca)	75 mg/L	200 mg/L	–
9.	Sulphate (as SO_4^{2-})	200 mg/L	400 mg/L	400 mg/L
10.	Nitrate (as NO_3^-)	45 mg/L	100 mg/L	10 mg/L
11.	Fluoride (as F^-)	1.0 mg/L	1.5 mg/L	1.5 mg/L
12.	Phenolic Compounds (as C_6H_5OH)	0.001 mg/L	0.002 mg/L	–
13.	Anionic Detergent (as MBAS)	0.2 mg/L	1.0 mg/L	–
14.	Mineral Oil	0. 01 mg/L	0.03 mg/L	–
15.	Alkalinity	200 mg/L	600 mg/L	–
16.	Boron	1.0 mg/L	5.0 mg/L	–
Micro Pollutants (Heavy Metals and Pesticides)				
17.	Zinc (as Zn)	5.0 mg/L	15 mg/L	5.0 mg/L
18.	Iron (as Fe)	0.3 mg/L	1.0 mg/L	0.3 mg/L
19.	Manganese (as Mn)	0.1 mg/L	0.3 mg/L	0.1 mg/L
20.	Copper (as Cu)	0.05 mg/L	1.5 mg/L	1.0 mg/L
21.	Arsenic (as As)	0.05 mg/L	No relaxation	0.05 mg/L
22.	Cyanide (as CN)	0.05 mg/L	No relaxation	0.1 mg/L
23.	Lead (as Pb)	0.05 mg/L	No relaxation	0.05 mg/L
24.	Chromium (as Cr^{6+})	0.05 mg/L	No relaxation	0.05 mg/L
25.	Aluminium (as Al)	0.03 mg/L	0.2 mg/L	0.2 mg/L
26.	Cadmium (as Cd)	0.01 mg/L	No relaxation	0.005 mg/L
27.	Selenium (as Se)	0.01 mg/L	No relaxation	0.01 mg/L
28.	Mercury (as Hg)	0.001 mg/L	No relaxation	0.001 mg/L
29.	*Total Pesticides*	Absent	0.001 mg/L	–

S. No.	Parameter	BIS, Indian Standards (IS 10500:1991)		World Health Organization, (WHO Guideline)
		Desirable Limit	Permissible Limit	Maximum Allowable Concentration
1.	Sodium	–	–	200 mg/L
2.	Aldrin anddieldrin	–	–	0.03 µg/L
3.	DDT	–	–	1.0 µg/L
4.	Lindane	–	–	3.0 µg/L
5.	Methoxychlor	–	–	30.0 µg/L
6.	Benzene	–	–	10.0 µg/L
7.	Hexachlorobenzene	–	–	0.01 µg/L
8.	Pentachlorophenol	–	–	10.0 µg/L

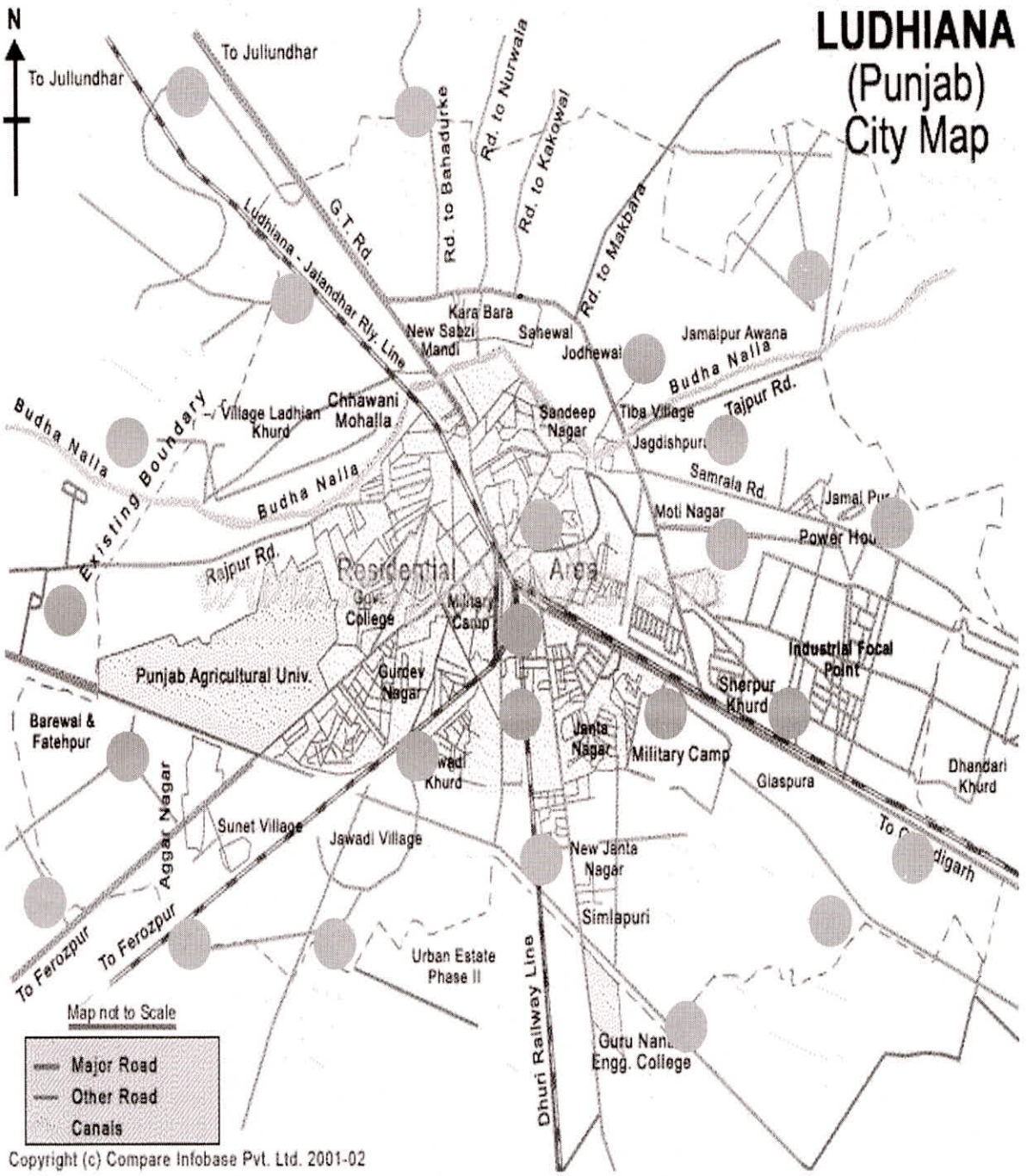

Fig. 1: Sampling Locations

RESULTS

The groundwater quality of the Metropolitan City of Ludhiana has been assessed to see the suitability of groundwater for domestic applications. The groundwater samples from hand pumps and tube wells collected during pre and post monsoon seasons and analyzed for various physico-chemical and bacteriological parameters, heavy metals, pesticides and poly-aromatic hydrocarbon. The hydro-chemical and bacteriological data was analyzed with reference to BIS and WHO standards. The quality of ground water varies from place to place with the depth of water table. The groundwater quality has indicated higher concentration of Potassium, iron, manganese and lead at few locations. The ranges of each parameter and percent violation of samples along with the observations/comments on ground water quality are presented in Table 3. No poly-nuclear aromatic hydrocarbon were detected in any of the ground water samples of the Ludhiana metropolitan city.

Table 3: Groundwater Quality Observation and % Sample Compliance/Violation with Respect to Drinking Water Standards in Ludhiana Metropolitan City

Sl. No.	Paramet-ers (All Values are in mg/L)	Range- (Pre-Monsoon)	Range (Post-Monsoon)	Stds. BIS/ WHO	% Sample Compliance/Violation	Observations
1.	pH value	7.1–7.6	7.2–7.6	6.5–8.5	None	• The pH values are well within the limit of various uses
2.	Total Hardness (as$CaCO_3$)	148–296	144–288	300–600	None	• The Total Hardness values are well within the limit of various uses
3.	Chloride (as Cl)	12–65	11.5–63	250–1000	None	• The Chloride values are well within the limit of various uses
4.	Total dissolved solids	322–498	331–523	500–2000	None	• The Total Dissolved Solids values are well within the limit of various uses
5.	Calcium (as Ca)	28.9–54	30.5–52.4	75–200	None	• The Calcium values are well within the limit of various uses
6.	Sulphate (as SO_4)	16.8–60.5	14.1–55.1	200–400	None	• The Sulphate values are well within the limit of various uses
7.	Nitrate (as NO_3)	4.27–30.6	4.10–28.21	45–100	None	• The Nitrate values are well within the limit of various uses
8.	Fluoride (as F)	0.71–0.92	0.70–0.86	1.0–1.5	None	• The Fluoride values are well within the limit of various uses
9.	Sodium (as Na)	29.5–78	35–81	200 (No limit in BIS/WHO)	None	• The Sodium values are well within the limit of various uses
10.	Potassium (as K)	2.5–15	3.1–17.3	No limit in BIS/WHO	EEC has prescribed guideline level of 10 mg/l potassium during pre-monsoon.	• In both the monitoring rounds the values of potassium exceeded the 10 mg/l of EEC standard at Kidwai Nagar, Sardar Nagar, Bhai R.S. Nagar, Shahi Mod. • The main sources of potassium in ground water include rainwater, weathering of potash, silicate minerals, use of potash fertilizers and use of surface water for irrigation.
11.	Magnesium (as Mg)	19.0–32.5	19.8–33.4	30–100 (BIS standard)	None	• The ranges in both the monitoring rounds indicate that Magnesium values are within the Stipulated standard at all the location(s); • For both the monitoring rounds the HP monitored at Guru R.D. Park Chowk, Fatehgarh, Sabzimandi, K.M. Singh, Langer Hall Daba and Model Town Mkt and Shahi Mhd. Exceeded the max. PL.
12.	Phosphate (as PO_4)	0.43–3.3	0.38–2.11	No limit in BIS/WHO	None	• Phosphorous is essential plant nutrient and is extensively used in fertilizers. Phosphate gets adsorbed or fixed as aluminum or iron phosphate in acidic soils or as calcium phosphate in alkaline or nutral soils, as a result the concentration of phosphate is usually low but various chemical processes in soil strata may induce the mobility of phosphate in subsoil and groundwater.
13.	Conducti-vity (as EC) µS/cm	439–1164	450–1178	1000 µS/cm (irrigation standard)	Almost all the sample having conductivity value below 1000 µS/cm during both the seasons but 4% remain > PL and 96% within the DL.	• There was no seasonal variation at almost all the locations. However, the value of conductivity exceeded the irrigation standards at most of the locations. • For both the monitoring rounds the HP monitored at Char Acre Colony. 2.5 No. Police Post Bhai R.S. Nagar, Gurudev Nagar Model Town Mkt Shahi Moh, Kitchlu Nagar Tajpur Road and Humbra Road exceeded the PL.
14.	Faecal Coliform MPN/100 ml	<2–<2	<2–<2	Should be nil		• All the values are well within the permissible limits.
15.	Total Coliform MPN/100ml	<2–4	<2–<2	5% samples Should not be >10 in 100ml sample.	None	• All the values are well within the permissible limits.
16.	Alkalinity (as HCO_3)	236–372	244–380	200–600	None	• There was no seasonal variation at almost all the locations. However, the value of alkalinity exceeded the permissible limit in 58% and 58% during pre and post-monsoon seasons respectively. • For both the monitoring rounds the HP monitored at MIG Sector 32A, Sherpur, Kailash Nagar, Kidwai Nager , Guru A.D. Park C. Chowk, Industrial Area-A, Narinder Nagar, Janta Nagar, Industrial Area-B, Darresi, Fatehgarh, Sabzimandi, N. Shivpuri, Panjabibagh, Gagan D. Colony, Janta Colony, Sardar Nagar K.M. Singh and Langar Hall Daba. are exceed the PL for drinking purpose whereas all the values well within the desirable limits.
17.	Boron as B	ND	ND	1.0–5.0	All the samples indicate that the ground water is safe for irrigation purpose only.	• All the samples are well within the Permissible and desirable limit.

	Heavy Metals (mg/L)	*Range (Pre-Monsoon)*	*Range (Post-Monsoon)*	*Stds. BIS/WHO (µg/L)*	*% Sample Compliance/ Violation*	*Observations*
1.	Iron as Fe	0.04–0.13	0.04–0.11	0.3–1.0	0% crosses PL during pre and post monsoon respectively.	• It is evident from the results that none of the sample fall within the PL during pre-monsoon season and post monsoon respectively. • In both the rounds of monitoring high concentration of iron observed in most of the samples during pre monsoon and violating permissible limits of drinking water standards.
2.	Magnesium as Mn	19–32.5	19.8–33.4	30–100	Only 21% crosses the PL during pre and post monsoon seasons.	• It is evident from the results 21% fall more then the PL during pre and post monsoon seasons;
3.	Copper as Cu	ND–.02	ND–0.03	5–25	Nil	• It is evident from the all the results falls well below the permissible limits during pre and post monsoon seasons;
4.	Chromium $^{+}$as Cr	ND–0.03	ND	0.05 No relaxation	Nil	• All the samples fall well within the PL of drinking water;
5.	Zinc as Zn	0.07–0.98	0.01–0.84	5–15	Nil	• The concentration of Zn in groundwater samples is within the stipulated standards.

	Pesticides (µg/l)	*Range (Pre-Monsoon)*	*Range (Post-Monsoon)*	*Stds. BIS*	*% Sample Compliance/ Violation*	*Observations*
			Organochlorinated pesticides			
6.	Aldrin	ND	ND	0.03 (WHO guideline)	All the samples are well within the WHO limit except one.-	• The concentrations of Aldrin were not detected in any of the groundwater samples.
7.	∝-BHC	ND	ND	1.0 (WHO guideline)	All the samples are well within the WHO limit except one.	• The concentrations of BHEC were not detected in any of the groundwater samples.
8.	Endosul-phan	ND	ND	No guideline	All the samples are well within the WHO limit except one.	• The concentrations of Endosulphan were not detected in any of the groundwater samples.
9.	DDT	ND	ND	2.0 (WHO guideline)	All the samples are well within the WHO limit except one.	• The concentrations of DDT were not detected in any of the groundwater samples.

Note: The abbreviation indicated above as 'DL' = Desirable Limit; 'PL' = Permissible Limit; EEC is = European Union Standard, 'HP = Hand pump; 'TW' = Tube well

CONCLUSIONS AND RECOMMENDATIONS

The following are the Conclusion and Recommendations of the study:

- A large number of industrial activities are taking place in urban areas, especially in congested, populated areas. The wastes generated by industrial activities in urban areas get mixed with domestic wastes and pollute the groundwater.
- The quality of groundwater with respect to bacteriological parameters in some of the pockets of Ludhiana showed bacterial contamination at few locations during pre-monsoon season. This can be attributed to in-adequate collection of sewage, garbage leading to accumulation of wastewater and garbage, inadequate maintenance of hand pumps, improper sanitation and unhygienic conditions around the structures and in the city limit may be responsible for bacterial contamination at few locations during the pre-monsoon season.
- With respect to physico-chemical properties of the samples collected, it is either conforming to desirable or permissible limits. The quality of ground water from a few shallow tube wells has been impaired in some of the areas. However, the deep bore/tube wells have not yet been affected.
- Groundwater quality with respect to critical chemical parameters such as Chloride, Total Dissolved Solids (TDS), Nitrate-N, Fluoride, Total and Faecal Coliforms and heavy metals are summarized. Groundwater quality with respect to critical metals such as Iron, Chromium, Copper, Manganese and Zinc and their compliance/ violations against drinking water standards in both the seasons. The percent compliance/ violation exercise includes analysis of total 50 samples in both the seasons at same locations in each metropolitan city.
- The Nitrate concentration (log value) revealed that Ludhiana, indicating below the permissible limit.
- Ludhiana did not showed any violation against drinking water standards and indicating chloride concentration within the desirable limit of drinking water standards.
- It is concluded that the TDS percent compliance in Ludhiana) did not indicate any violation with respect to total dissolved solids.
- Fluoride in Ludhiana did not show any percent violations.

- Percent compliance/violations against drinking water standards with respect to heavy metals revealed that the Iron (Fe) indicates violations in almost seven metros except Ludhiana.
- As clear from the results, Zinc did not show any violation in any of the Metropolitan city.
- Pesticides analysis indicated the presence of α-BHC, β-BHC, γ-BHC Endosulphan and methoxy-chlor in ground water of the metropolitan city but their content was well within the permissible limits of World Health Organization (WHO) for drinking water.
- In order to minimize over-abstraction and deterioration of ground water quality all the ground water extraction structures should be registered and regulated.
- Possibilities of construction of artificial recharge structures should be explored to augment the ground water recharge.
- The hand pumps, which have been identified as having suspected water quality should be painted red to indicate and warn the public that the water drawn from the source is not fit for human consumption.
- The ground water drawn from hand pumps should be properly chlorinated to eradicate the presence of bacterial contamination.
- The untreated sewage and sewerage flowing in various open drains are one of the causes of ground water quality deterioration. Proper under ground sewerage system must be laid in all inhabited areas and the untreated sewage and industrial wastes should not be allowed to flow in open drains.
- A regular monitoring of Groundwater quality should be done in the areas where water was found contaminated in metropolitan cities. Proper collection and treatment of wastewater and proper collection and disposal of municipal solid waste should be done. Industrial activities specially, polluting industry should be prohibited in residential areas. No stagnation of wastewater should be allowed to avoid percolation of contaminants in groundwater.
- Disposal of hazardous waste or biomedical waste should be prohibited in the city limit to avoid any leaching process in to the groundwater or to provide engineered landfill, if it is within the city limit. Three major contaminants were observed in the metro-cities i.e. Chlorides, Nitrates and Coliform bacteria. Wherever such contaminants were observed, the water should be used especially for drinking only after de-contaminating.
- It is suggested that some low cost and easy to implement techniques may be provided to the consumers for removing hardness, total dissolved solids arsenic, fluoride, coliform and chloride in water where the value exceeds the permissible limit of drinking water.

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