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Quality of Water in and Around Chandigarh Region – A Review

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Abstract It is well documented that water is an essential component for the survival of all living beings and development processes on earth. Water is used for domestic purposes, industrial processes and agriculture. All these processes require good quality water. River water and underground water is generally used for almost all these processes. So it is very important to know the water quality of sources time to time for the sustainable development. In this paper we have discussed the quality of ground water, surface water and river water of Chandigarh and nearby places such as Parwanoo, Panchkula, S.A.S. Nagar (Mohali) on the basis of reports available online. The different water quality parameters such as hardness, alkalinity, Ca^{2+}, Mg^{2+}, BOD, COD, TDS, pH, conductivity, temperature etc was considered for this review study. Although very few studies have been conducted to check the water quality of this area but on carefully reviewing the available reports and published work, it has been observed that the water quality in some of the places is below the standards of water quality prescribed by Bureau of Indian Standards (BIS). Proper functioning of Sewerage Treatment Plants (STPs) need to be checked and Industrial waste should be properly treated before going to the catchment areas.

Keywords: Water quality, hardness, river water quality, BOD, COD, sewerage treatment plant

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1. INTRODUCTION

Quality of water refers to the biological, chemical and physical characteristics of water *(Diersing Nancy 2009; Mary et al. 2011)*. It is a measure of the condition of water relative to the requirements of one or more biotic species to any human need *(Johnson, 1997)*. Sources of drinking water are subjected to contamination and require appropriate treatment to remove disease-causing contaminants. Contamination of drinking water supplies can occur in the source water as well as in the distribution system even after water treatment process. The presence of contaminants in water can lead

to adverse health effects like gastrointestinal illness, reproductive problems, and neurological disorders in people with weak immune systems.

In recent years, the interest in water quality control has increased considerably, since water quality interventions have a great influence on all living organisms including human. Although water covers 80% of the earth surface but only 1% is available to use directly without any purification. The composition and concentration of substances in ground and surface water is a resultant of geological structure of the earth's crust and anthropogenic activity associated with agriculture, industry and public utilities (*Lahiry, 1996*). As water travels through the soil's profile, various water-soluble substances are added with water (*Pulikowski et al.* 2006).

High level of alkalinity in industrial phases make water unpalatable and the soil is affected by percolating water (*Sawyer and McCarty, 1967,Sundaray et al., 2009*). Generally degree of hardness is categorized into soft (0 to 60 mg/L), moderately hard (60 to 120 mg/L), hard (120 to 180 mg/L) and very hard (180 mg/L) *(Durfer and Backer,* 1964). The optimal range of hardness in drinking water is from 80-100 mg/L. In areas where drinking water is harder than 500 mg/L, higher incidence rates of gallbladder disease, urinary stones, arthritis and arthropathies (*Memon et al.*, 2011 ; *Muzalevskaya et al.* 1993), and cancer (*Memon et al.*, 2011; *Golubev and Zimin* 1994) have been reported. So, regular monitoring of water quality is required.

There are different specifications of water for different uses. Water for domestic use should be clean, colorless, odorless and free from disease producing microorganisms. Its total hardness should not exceed the limit of 600 ppm while pH should be in the range of 6.5-8.5 *(Palanna, 2009; BIS, 2009)*. Bureuo of Indian Standards (BIS) has prescribed some standards for drinking water quality. Standard as well as permissible limits (IS 10500 second revision, 2009) of some of the parameters are provided below in the table (Table 1).

Generally water quality can be checked by analyzing water samples for the concentration of above parameters, heavy metals and microorganisms. The purposes and intent of the water quality related research is to provide better water quality and prevent it from pollution (*Balan, 2012*). Water quality research also help to maintain the water quality for agricultural, industrial, recreational and other reasonable and necessary uses and to maintain and improve the biological integrity of the waters of the region conservation of fishes, wildlife and other beneficial aquatic life, *(EPA's Water Quality Standards 1993)*.

In this review paper we have summarized the findings of water quality studies conducted in Chandigarh, Panchkula, S.A.S. Nagar (Mohali) and Parwanoo by various researchers.

Table 1: Drinking water standards (IS 10500 second revision, 2009) for different water quality parameters.

S. No.	Parameters	Standard Value	Permisible values
1	pH	6.5 – 8.5	No relaxation
2	Turbidity (NTU)	1	5
3	Total Dissolved Solids (mg/L)	500	2000
4	Total Hardness (as $CaCO_3$, mg/L)	200	600
5	Sulphates (mg/L)	200	400
6	Magnisium (mg/L)	30	No relaxation
7	Nitrate (mg/L)	45	No relaxation
8	Chloride (mg/L)	250	1000
9	Residual Free Chlorine, (mg/L)	0.2	1
10	Calcium (mg/L)	75	200
11	Total Alkalinity (as $CaCO_3$, mg/L)	200	600

Table 2: Description of areas selected to review the water quality and their grid location

Sr. No.	Region/Place	Location
1.	Chandigarh, Union Territory	30° 43′ N/ 76° 46′ E
2.	Panchkula, Haryana	30° 41′ N/ 76° 51′ E
3.	S.A.S. Nagar (Mohali), Punjab	30° 42′ N/ 76° 43′ E
4.	Parwanoo, Himachal Pradesh	30° 50′ N/ 76° 57′ E

2. CHANDIGARH REGION

Chandigarh city with a population of 10,55,450 (as per 2011 census), is located in the fringes of the Shivalik range at 30° 43' N latitude and 76° 46' E longitude. The area falls under the Indo-Gangetic plain, a few miles south of the Shiwalik Hills and between two seasonal hill torrents, Sukhna Choe and Patiali Rao. The land of the area is a flat and fertile tract of alluvial soils. It covers an area of approximately 114 km² and shares common boundaries with the states of Haryana in the south and east and Punjab in the north and west.

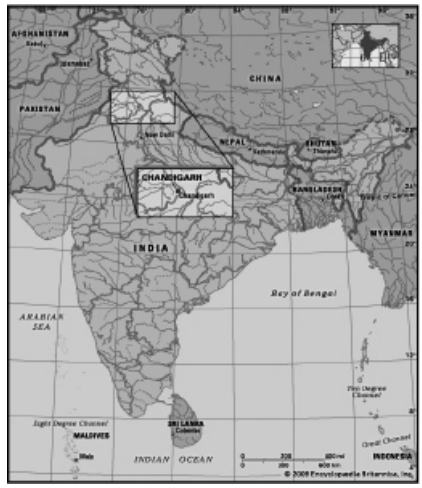

Figure 1: Map showing the location of Chandigarh region

The temperature varies between 0°C to 44°C while average annual rainfall remains near about 105 cm. It also receives occasional winter rains from the western chaos.

Underground water through tube wells and Bhakra main line flowing at a distance of 27 Kms from Chandigarh city are the two main sources of water supply in Chandigarh region to meet the growing requirement. Chandigarh city is a beautifully planned city with good network of roads. It also has a specified area in its vicinity for small Industrial Units. A few studies have been conducted on the water quality of this area.

A study was conducted in 2012 by Simranjit Kaur and Promila Malik (*Simranjit Kaur and Promila Malik, 2012*) to check the water quality in different sectors of Chandigarh. This study indicates the effect of chemical pollution on surface water and ground water in industry dominating sectors of Chandigarh. In this study, samples of surface water (SW) and ground water (GW) were collected in the month of November, 2011 from different locations of Chandigarh and analyzed for temperature, pH, alkalinity, total hardness, dissolved oxygen, chemical oxygen demand (COD), calcium and magnesium. Results obtained in this study from the analysis of water samples are presented in the Table 3.

This study showed that the temperature of water in industrial areas was higher than the temperature of water in other sectors of Chandigarh. Slightly acidic character of surface water was observed in the study. High values of total hardness (200-400 mg/L) have been reported in groundwater (GW) and surface water (SW) samples and consequently the GW as well as SW at all the sampling sites was considered hard due to high amount of hardness. In non-

Table 3

Sr. No.	Parameter	Sectors-22,35,38,42,44,48		Industrial Phase I, II	
		SW	GW	SW	GW
1.	Temperature (°C)	22 – 27	20 – 25	26 – 28	24 – 25
2.	pH	6.4 – 6.8	7.0 – 7.2	6.3 – 6.5	6.9 – 7.1
3.	Total Hardness (mg/L)	250 – 350	200 – 350	375 – 400	275 – 300
4.	Alkalinity (mg/L)	500 – 650	400 – 500	700 – 1100	500 – 750
5.	DO (mg/L)	4 – 7	7 – 11.6	3 – 4	5 – 6
6.	COD (mg/L)	25 – 40	10 – 15	45 – 50	15 – 17
7.	Ca (mg/L)	120 – 180	130 – 220	120 – 240	98 – 220
8.	Mg (mg/L)	27 – 60	23 – 40	60 – 70	35 – 45

industrial areas, the concentration of magnesium in surface water varied from 27-60 mg/L while concentration varied between 23-40 mg/L in ground water samples. The magnesium concentration was quite high in industrial water samples. Low concentration of dissolved oxygen has been reported in SW samples in the industrial phases. High calcium concentration was also reported in the area.

Another study was conducted by Neelam Sidhu and co-workers in 2013 (*Neelam Sidhu et. al., 2013*). They monitored the differences in the composition of the groundwater taken from shallow and deeper aquifers within the study area. Shallow aquifer system in the study area was found more contaminated as compared to the deeper aquifer system. In this study groundwater samples were collected from shallow and deeper aquifers during pre- and post-monsoon periods in the year 2012 from different sites of Chandigarh. These samples were analyzed for the pH, EC, TDS and the major ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, F^-, Cl^-, HCO_3^-, CO_3^{2-} and NO_3^-) using APHA methods (APHA, 2005). Analysis of this study has been shown in Table 4.

Elevated concentrations of EC, TDS and TH in shallow water samples were reported in this paper. Water was alkaline in both deeper and shallow aquifer as indicated by the values of pH (7.52-7.58). The levels of electrical conductivity (EC) show that shallow aquifer was more mineralized as compare to deeper aquifer. High TDS values and hardness were reported in shallow aquifer samples. Highest value of calcium was recorded in the sample taken from village Hallomajra. The concentrations of nitrate were found to be higher in shallow aquifers as compared to deeper aquifer. The concentration of Ca^{2+},

Table 4

Sr. No.	Parameter	Deeper Aquifer Depth (70-202 m)	Shallow Aquifer Depth (15-30 m)
1.	pH	7.58	7.52
2.	EC(µS/cm)	493.25	696.5
3.	TDS (mg/L)	281.75	391
4.	TH (mg/L)	186.6	266.19
5.	Ca^{2+} (mg/L)	51	89.57
6.	Mg^{2+} (mg/L)	15.4	15.52
7.	Na^{+} (mg/L)	40.3	39.76
8.	K^{+} (mg/L)	1.59	2.4
9.	Cl^{-}(mg/L)	14.5	28.04
10.	HCO_3^{-}(mg/L)	287	333.23
11.	F^{-} (mg/L)	0.32	0.19
12.	SO_4^{2-} (mg/L)	9.95	31.28
13.	NO_3^{-} (mg/L)	4.6	13.47

Mg^{2+} and NO_3^{-} was found within the prescribed limits for drinking water (BIS standards).

3. PARWANOO REGION

Parwanoo (30’ 50 °N 76’ 57°E) with a population of 8,609 (2001 census) is an industrial town in district Solan of Himachal Pradesh, India. It borders Panchkula district of Haryana and is separated by a river bed from the town of Kalka, Haryana. Parwanoo to Pinjore (after Kalka towards Panchkula city) is almost a continuous urban belt. Parwanoo has different types of industries such as plastic industries, chemical industries and electronic industries. Kaushalya River is an important source of water supply for Parwanoo town. Some natural waters in the areas of Dharampur and Dakshai contribute to form this river which flows through Jabli, Koti, and Parwanoo and finally joins Ghaggar river.

A study was conducted by Rhythm Aggarwal and Shakti Arora (*Aggarwal R. and Arora S., 2012*) to check the water quality of Kaushalya River in

Parwanoo**.** In this study river water samples were collected and analyzed for physicochemical and bacteriological evaluation of pollution. The water quality was studied quarterly at two sites at upstream and downstream regions during 2011 in the months of January, April, July and October. The physiochemical analyses of water samples were performed using standard analytical methods for the examination of water and wastewater (*APHA, 2005*). The results obtained in the study are presented below in Table 5.

Table 5

Sr. No.	Parameter	Jan-2011	Apr-2011	Jul-2011	Oct-2011
1.	Temperature (^oC)	14.9-15.5	22.5-23.0	23.5-24.2	21-21.4
2.	pH	7.6-8.11	7.75-7.96	8.1-8.19	7.33-8.29
3.	Electrical Conductivity (EC), µS/cm	222-225	258-286	305-317	238-247
4.	Dissolved Oxygen (DO), mg/L	9.5-9.9	8.9-9.2	7.2-7.6	8.5-8.9
5.	Biological Oxygen Demand (BOD), mg/L	0.4-0.5	0.1-0.3	0.1-0.2	0.4-1.0
6.	Chemical Oxygen Demand (COD), mg/L	3.8-20.0	4.5-24.4	0.4-1	3-8
7.	Total Hardness (TH), mg/L	145-160	130-150	155-176	140-156
8.	Total Alkalinity (TA), mg/L	234-250	255-306	273-283	290-330
9.	Calcium (Ca), mg/L	48.44-56.00	47.98-56.85	59.83-70.25	30-40
10.	Magnesium (Mg), mg/L	4.8-6.2	1.85-2.43	1.04-1.49	13.65-16

The increase in COD values (3.8-20.0 mg/L) with downstream indicated the increase in pollution in the river. The increase in pH (8.29) in downstream seems to be due to greater input of waste from sewage of Parwanoo. Hardness increases (176mg/L) with downstream which may cause scaling in boilers. High alkalinity (330 mg/L) may cause problems if water is used for irrigation purposes. So, the data of COD, Hardness, and Alkalinity shows that this water is unfit for domestic and commercial purposes and cannot be used without prior treatment.

Studies have been conducted by state and central pollution control boards to check the water quality of major rivers of the region (*ADSORBS, 2010; HPPCB 2008, 2012*). Study conducted by Himachal Pradesh Pollution Control

Board (HPPCB) in 2011-2012 showed almost similar results (with little increase) as reported by CPCB in 2010 for Kaushalya River. Central Pollution Control Board (CPCB) has also published a report on pollution status of river Ghaggar (*ADSORBS, 2010*)**.** This report covers the water quality of Ghaggar River from Parwanoo in Himachal Pradesh where Kaushalya River, the main source of River Ghaggar joins it to STP Diggian, Mohali. Various physio-chemical parameters such as DO, COD, BOD, pH were analyzed in this study (Table 6). Analysis of pollution load of Ghaggar Basin from drains at Sukhna Nallah showed the high value of COD (18 mg/L) and BOD (7 mg/L). Highest values of TDS, BOD and COD have been reported in the assessment from STP, Kalka.

Table 6

		CPCB Report, 2010					**HPPCB Report, 2012**
Sr. No.	Parameter	Pollution Assessment at the source, Kaushlaya River (HP)	Pollution Assessment from STP, Kalka, H.R.	Pollution Assessment at Amravati Enclave, Panchkula, H.R.	Pollution Load from Drains at Sukhna Nallah	Pollution Assessment from STP Diggian, Mohali, Pb.	Kaushalya River at Parwanoo. H.P.
1.	Total Suspended Solids (TSS) mg/L	---	228	----	----	46	---
2.	BOD (mg/L)	1	393	1	7	22	0.6
3.	COD (mg/L)	2	921	5	18	120	---
4.	pH	7.5	7	7.5	7.3	6.9	8
5.	DO (mg/L)	7.8	---	7.4	---	---	8.96

--- data not available

4. PANCHKULA REGION

Panchkula city, the district head quarter of Panchkula district (total population of 561293) in Haryana is a planned city situated near Chandigarh, India. It has the boarders with Panjab and Himachal Pradesh states district has a sub tropical continental monsoon climate having, hot summers, cool winters and good monsoon rainfall. It has great variation in temperature (6°C to 40°C). The

rainfall is mostly received in the monsoon season. The district also receives winter rains from the western disturbance. **Morni** hills constitute the highest point of the district as well as of Haryana. The **Ghaggar** is the only perennial river, which is very shallow outside of the monsoons. Generally the slope of the district is from north east to south west and in this direction, most of the rivers/ streams rainfed torrents flow down and spread much gravel and pebbles in their beds. The soils in the district are mainly light **loam** *(panchkula.nic.in)*.

The study conducted by Central Pollution Control Board (CPCB) also covers the water quality of Ghaggar River of this area (*ADSORBS, 2010*). In this study sampling points from the possible sources were selected as outlets of drains, Sewage Treatment Plants (STPs) and industries and confluence points of the river with its tributaries and the analysis of various parameters has been shown in Table 6. STP, Kalka need to be efficiently operated as high value of TSS (228 mg/L), BOD (393 mg/L) and COD (921 mg/L) has been observed during the study. The effluent quality of these STPs does not comply with rules to the prescribed standards for BOD and TSS.

5. S.A.S. NAGAR (MOHALI) REGION

S.A.S. Nagar (Mohali) is a city in Punjab and a commercial hub lying adjacent to **Chandigarh** city. It has a **sub-tropical** continental **monsoon climate** characterized by a seasonal rhythm: hot summers, slightly cold winters, unreliable **rainfall** and great variation in **temperature** (6°C to 44 °C). The average annual rainfall is recorded at 617 millimeters. The city also receives occasional winter rains from the west. The Ghaggar river and its tributaries form the natural drainage system in Derabassi block of the district. While north-eastern part is drained by Siswan Nadi, Jainti Devi Ki Rao and Patiala Ki Rao, which emerge from the Siwalik Hills. The Siswan Nadi drains the northern part of the district and finally converges with Sutlej river in the Ropar district while Jainti Devi Ki Rao and Patiala Rao drains in NE-SW direction and joins the Ghaggar River (*cgwb.gov.in*).

The report published by Central Pollution Control Board (*ADSORBS, 2010*) also includes the pollution status of river Ghaggar. In this study the analysis of water from Sewerage Treatment Plant (STP), based upon MBBR (Moving Bed Biofilm Reactor) technology Diggian located at sector 66 of S.A.S Nagar (Mohali), Punjab, is conducted**.** This place is a source of sewerage discharge in Ghaggar river. Source of sewerage is Sector 20,21,43,44,47,48, 36,50,51 ,52,49,61,62,64,80,81,83 of Chandigarh city **(***Prerna Sharma et al., 2013***).** The Pollution assessment of Ghaggar basin from this STP has been shown in Table 6. High value of COD and BOD indicates that STP, Diggian Mohali, is not working efficiently and need to be efficiently operated.

6. CONCLUSION

From the review of available reports and research papers on the water quality of selected regions, it can be concluded that water should not be used directly without proper purification. The levels of water quality parameters at some places are not within the safe range as prescribed by the WHO and BIS. The water needs prior treatment before being used for household and commercial purposes. The water may cause undesirable effects on public health and environment if consumed directly without any treatment. Higher values of hardness and TDS may cause adverse impact on the health of residents. High value of COD indicates the poor quality of water.

Functioning of sewerage treatment plants needs to be checked so that proper treatment of industrial wastes and sewerages can be done before discharge into nearby water bodies and catchment areas. It would reduce the risk of surface water and ground water pollution in this region**.** There is a great scarcity of the water quality research in this region hence more studies need to be conducted using highly sophisticated instruments for more accurate and authentic results.

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