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Understanding the Impact of Industrialisation on Potable Water Quality in the Lower Shivalik Region of Himalayas and its Geographical Analysis

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Abstract: Shivalik region is well known for increasing industrialisation subjected to govt. policies and other factors for setup. Massive industrialisation has a serious impact on the natural resources and surroundings. In the study, the effect of these industries has been studied on water resources. Various physiochemical parameters viz. pH, conductance and others were determined to ensure the quality of water. The concentration of heavy metals was estimated through Atomic Absorption Spectrophotometer (A.A.S). Findings revealed shocking facts about the drastic change in the physiochemical parameters including metal-ion concentrations. The level of these metal-ions was found to be much higher than permissible limits and can be subjected to untreated effluent from the industries. Survey results have been merged liable on personal observations and the interaction with stakeholders.

Key words: Heavy metals, socio-economic impact, survey, chemical analysis.

Introduction

Water is fundamental building component for all types of life and is vivacious for the conservation of life on earth including both flora and fauna for the regeneration, recovery of cells and other psychological activities in mother nature (World Health Organization). More than 66 per cent of the world's surface is covered by water, however, most of the part is salty and undrinkable. The accessible freshwater asset is just 2.7 per cent of the accessible water on earth. However, just 1% of the accessible freshwater (in lakes, waterways and groundwater) is open (Hinrichsen, 2002; World Health Organization, 2000). Prominently, drinking water ought not to have any organisms known to be pathogenic-equipped for causing illness or any microbes demonstrative of faecal defilement. Sodium salts are not exceptionally poisonous in light of the proficiency with which mature kidneys discharge sodium (Karavoltsos, 2008; Sinclair, 2009; Singh, 2018). Unnecessary salt admission genuinely disturbs ceaseless congestive cardiovascular breakdown, and sick impacts because significant levels of sodium in drinking water has been reported (World Wellbeing Association (WWO),

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1979). As per an estimate by WHO, South East Asia has the second-highest burden of foodborne diseases after Africa (Europe, 1979; World Health Organization, 2015). It is estimated that two million deaths occur every year from contaminated food or drinking water. Potable water is defined as water that is suitable for human consumption (i.e., water that can be used for drinking or cooking) (Dugan, 2012; National Research Council, 1987; Venkatramanan, 2014). Industrialisation has badly affected the natural resources mainly the water source through untreated discharge of effluents directly into the water bodies (Kaur, 2019). The significant problem of the region in the study area is the proliferation of macro, micro and small enterprises that are involved in chemical, pharmaceutical, or textile production. The rapid growth of industries due to incentives has increased the rate of pollution and poses a severe hazardous problem in the form of air, water and hazardous waste because, unlike larger industries that possess better technologies for waste disposal, small-scale industries dispose off the same in a hazardous manner (Berthelsen, 1995; Chang, 1984; Singh, 2021). These industries are mainly source of effluents like dyes and heavy metal used in manufacturing processes (Patel, 2021; Singh, 2020).

The BBN (Baddi-Barotiwala-Nalagharh) region has been a boon to companies due to state subsidies. Due to incentives, several enterprises have moved to the valley, and more than half are operating without a legal license or effluent treatment plants (Deepali, 2012). Therefore, investigating the physico-chemical parameters of the drinking water in this area is very important (Chopra, 2014; Momodu, 2010). In this work, drinking water samples are collected from the specific sites of the study area and have been analysed by various analytical techniques to estimate the water qualities as per standards.

Salient Feature: Study Area

In the geographical context, Shivalik means outer (lower) Himalayas comprising the lower hills of Kangra, Hamirpur, Una, Bilaspur and lower parts of Mandi, Solan and Sirmaur districts. The altitude of this zone varies from 250 metres to 1500 metres above mean sea level (Balokhra, 1999). The minimum temperature in the Shivalik hills is 5°C in January (winter) and the maximum in June up to 40°C (summer) (Balokhra, 1999).

Deforestation is also widespread due to the pro-industry of Himachal government policies. Himachal Pradesh pushed for industries aggressively between 1980 and 2004 due to industrial incentives. Himachal Pradesh Industrial Investment Policy, 2019, and Rules Regarding Grant of Incentives, Concessions, and Facilities for Investment Promotion in Himachal Pradesh 2019. These policies offer concessions and incentives for enterprises to locate in this resource-rich region. The present study is undertaken in three industrial zones of Himachal Pradesh.

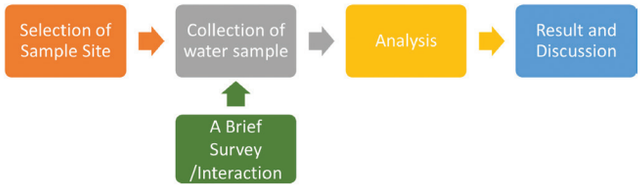
Zone 1: This zone is located in the Sirmaur district covering a stretch of about 50 km of the industrial region and is developed into a pharmaceuticals and chemical hub. The main cluster of industries is located in Kala-Amb and Paonta Sahib. Both places have a very high level of pollution. The industrial town of Kala-Amb is famous for discharging untreated waste and industrial effluent into the Markanda River which is a tributary of the Ghagger River.

Zone 2: This zone is located in the Solan district and is the largest industrial sector in Himachal Pradesh. This zone can be subdivided into two general areas i) the belt running from Parwanoo in the south to Nalagarh in the north and ii) the belt running north-east from Parwanoo towards Solan central city. This zone comprises—a) Baddi which has many pharmaceutical, textile, automobile, paper and printing units; b) Barotiwala which is a hub of small scale industries (SSI) and c) Parwanoo which has developed into light engineering industrial cluster for high-density polyethylene (HDPE) pipe companies.

Parwanoo and BBN are the fastest-growing regions of Himachal Pradesh. BBN is known as the largest pharmaceutical hub in Asia (Outlook, 1995). Industrial operations from Parwanoo to Nalagarh along the Shiwalik foothills have created an urban agglomeration. Nearness to Chandigarh, linkage to Kalka railway station, a significant railway station in North India, ample developable land, easier accessibility, and availability of basic infrastructure have also boosted industrial activity.

The above graph (Figure 1) shows that due to the HP government's incentives and flexibility in Industrial Policy, micro and small scale firms are increasing in every district.

From the graph (Figure 2), it's apparent that large-scale industries are moving from Sirmaur to Solan and a few to Una. Due to the location of Solan, many significant industries moved from Sirmour. Solan is a big industrial hub compared to Sirmour, luring firms with incentives.



Scheme 1: Methodology employed for this work.

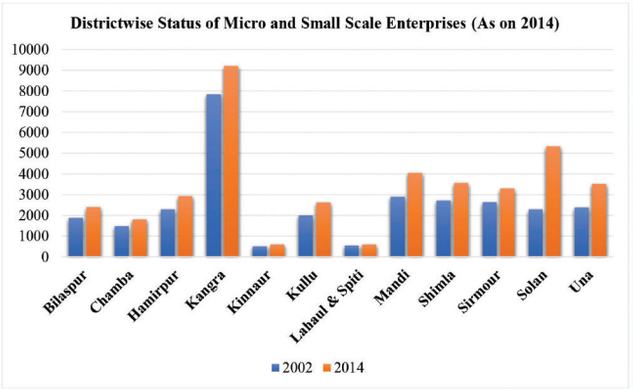


Figure 1: District wise status of micro and small-scale enterprises (2014).

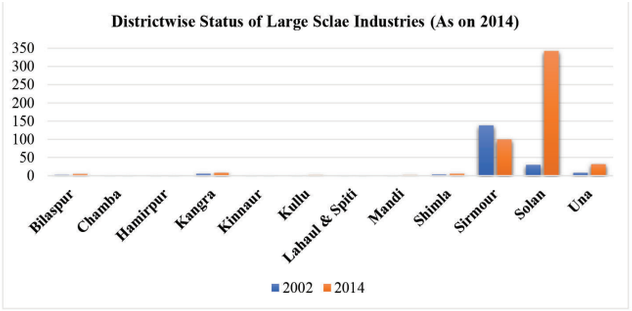


Figure 2: Districtwise status of large scale industries (2014).

Sarsa (Sirsa) River

Sarsa is the perennial river flowing from Nalagarh and Solan which is also the industrial stretch of the region. It finds its source in the foothill of Kasauli near Kalka in Haryana. It's 54 km long and runs into Himachal Pradesh via Baddi, 28 km away. According to the Himachal Pradesh Pollution Control Board, between 2013 and 2018, the catchment region of the Sarsa River revealed 2000 cases of gastroenteritis, 15,000 cases of kidney infection, 7000 episodes of diarrhoea, and 190 cases of cancer (Herojeet, 2016).

A 2011 study by Panjab University assessed the groundwater of the BBN Area, revealing that levels of iron, lead, copper, manganese, and alkalinity had crossed desirable limits, and in some cases, even permissible limits (Kamaldeep, 2011).

Swan River

Swan River is a Sutlej tributary known as the River of Sorrow owing to flooding. It runs north-southwest (Sharda, 2013). Gagret, Una, Mehatpur, and Santokhgargh are on the Swan river. It's 85 kilometres long and has a 1400 km^2 watershed (Thakur, 2018). It's used for domestic, industrial, and irrigation purposes in the Una district (Sharda, 2013).

Markanda River

Markanda is a Yamuna tributary in Himachal Pradesh's Nahan. Kala-Amb, near the Haryana border in Sirmaur District, has 350 industrial units (Kashyap, 2015). Pharmaceutical, chemicals, ghee, food, ferroalloy, paper, pulp, etc. are found in this region. Untreated effluents are an issue for surrounding neighbours, whose animals suffer from water-borne ailments.

Methodology

The following figure briefly represents our study methodology:

Study Area

The study area is separated (Scheme 1) into three regions, predominantly lower Shivalik.

Collection of Samples

Water samples were taken from residential areas (1 km) near industrial zones. Samples were maintained at room temperature in 1 L bottles.

Physical Measurements:

All the physical parameters viz. conductance, pH, and conductance were determined on site using Khera's Soil water analysis kit.

Heavy Metal Ions Concentrations

Water samples were taken and dried with evaporation and further diluted with double distilled water and acidified with 10 µL concentration of HNO_3. The studies give a three-replicate average with a standard deviation.

Methodology for Primary Survey

A primary survey was carried out with the residents in the form of a questionnaire and interviews regarding drinking water. Based on pollution, a survey was outlined which helped in taking contributions from the nearby residents about their evaluation of the ecological impact.

Results and Discussion

Geographical Analysis

BBN Industrial Area

BBN is the major centre of the economy of Himachal Pradesh with Baddi as one of its Municipal Corporation (Table 1). As per the provisions of HP Town & Country Planning Act, 1977, out of the 25 percent of BBN Special Area, 25 percent is not suitable for development purposes as it is covered by water bodies, forest and undeveloped land. Out of the total land, 15 percent is already developed under various urban land use forms such as residential, commercial, industrial, public and semi-public and park and open space. Baddi region is classified as a 'Severely Polluted Industrial Cluster' by CPCB which is a cause of concern and for which NGT has directed the state government and Himachal Pradesh Pollution Control Board (HPPCB) for making a policy framework. The Comprehensive Environmental Pollution Index (CEPI) Score is 69.07 (Haryana State Pharmacy Council Board, 2018a).

Table 1: Land use detail of BBN

S. No.	*Type of Plots*	*Total Nos*	*Allotted*	*Vacant*
1	Industrial Shed	20	20	0
2.	Industrial Plot	865	850	15
3.	Housing Plot	0	0	0
4.	Commercial Plots	0	0	0
5.	Housing Quarters	0	0	0
6.	Shops	84	84	0
7.	Godown	0	0	0

Source: H.P Industries Department

The BBN area is located in the foothills of Shivalik characterised by plain topography dissected by khuds and nallahs. Dharampur, Surajpur-Haripur-Mandhala, and Shivalik hills surround the area. As per the 2011 Census of India, the BBN area has a total population of 81,109 persons in a total of 121 villages. BBN includes Reserved, Protected, unclassified, and other forests. BBN has a 6507.27 hectare area that encompasses the Nalagarh and Baddi mountains. BBN contains 3120 hectares of Reserved Forest and 8664 hectares of dense forest (Haryana State Pharmacy Council Board, 2018a).

According to Table 2, 2261 industries are located in the BBN Area, of which 98 are Red Industries and 13 are Large Industries. 1099 Green Industries are small, while 61 are significant. The industrial units operating in the Baddi industrial area are given in Table 3.

Table 2: Classification of industries in BBN area

Industries	*Large*	*Medium*	*Small*	*Total*
Red	13	24	61	98
Orange	24	106	711	931
Green	61	77	1099	1232
Total	98	207	1871	2261

Source: H.P Industries Department

Table 3: Classification based on highly polluting industries

S. No.	*Type of industries*	*No. of industries*
1.	Cement(>=200 TPD)	4
2.	Distillery	1
3.	Pulp and Paper (>= TPD)	1
4.	Bulk Drug	1
	Total	7

Health Statistics of BBN Area

Based on the data collected from the secondary sources, health statistics data received from the local hospitals have shown the following results in the BBN Area.

From the analysis shown in Table 4, it is clear that there is no major trend that can be figured out from the data. The reasons can be many such as it is only taken from government local hospitals, and data regarding private hospitals are not available. Also, some people prefer to consult with other private practitioners and also visit Chandigarh PGI for health treatment. Thus, the unavailability of data is a major hindrance to drawing any conclusion in this regard.

Table 4: Water borne disease

Water borne diseases	*2013-14*	*2014-15*	*2015-16*	*2016-17*	*2017-18*
Gastroenteritis	7268	5120	3456	5870	5466
Diarrhoea	13511	7578	7292	2748	5715
Renal Diseases	8734	4064	2078	2601	1959
Cancer	124	27	16	8	15

Source: H.P Industries Department

Parwanoo Industrial Cluster

Parwanoo is an industrial town with having Municipal Council lying in the Solan district of Himachal Pradesh. It derives its name from the 'Parwanun' Hill

in its vicinity (Haryana State Pharmacy Council Board, 2018b). Almost 80 percent of its population is engaged with industries in different forms. The largest fruit processing unit of H.P. Horticulture Produce Marketing & Processing Corporation (HP State Government Undertaking) popularly known as HPMC is located here and the Cattle Feed Unit and a Pesticide Unit of HP Agro Industries is also situated here. The CEPI Score of Parwanoo is 63.83 and it is one of the 'severely polluted industrial clusters' identified by CPCB. The total geographical area of Parwanoo Municipal Council is 9 km^2. It's 22 kilometers from Chandigarh on NH-22. This zone has tectonically active slopes, considerable relief, and immature topography. Bulk Drug, Metal Finishing, electroplating, Phosphating, and Pesticide Formulations are important red industries in Parwanoo (Tables 5 and 6).

Table 5: Land use detail of Parwanoo

S.No.	*Type of plots*	*Total nos.*	*Allotted*	*Vacant*
1.	Industrial Shed (Department of industries)	37	37	0
	Industrial Shed (HPSIEC Ltd.)	8	8	
2.	Industrial Plot (ownership of HIMUDA)	283	283	0
	Industrial Plot (Department of Industries)	5	5	
3.	Housing Plot	0	0	0
4.	Commercial Plots	0	0	0
5.	Housing Quarter	0	0	0
6.	Shops	9	9	0
7.	Godown	0	0	0

Analysis of Potable Water

While collecting the samples at the site few parameters were recorded and results have been shown below in the labelled graphs. Following are the parameters that have been studied.

Table 6: Classification of industries in Parwanoo industrial cluster

Industries	*Large*	*Medium*	*Small*	*Total*
Red	04	04	08	16
Orange	15	17	13	45
Green	06	18	429	453
Total	25	39	450	514

Source: H.P Industries Department

pH of the Water

The standard pH esteem suggested by WHO present drinking water differs between 6.5 and 8.5 contingent on the kind of topography of the district. In the present investigation, the pH (Figure 3) worth of tests gathered from every one of the sources in the area changes between 7.4 and 8.22 which shows that the pH esteems have fulfilled the drinking water guidelines.

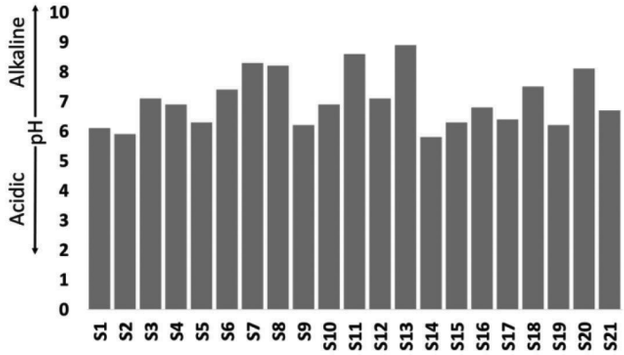


Figure 3: pH of various water samples.

Conductance of the Water Samples

WHO suggests the worth of in the scope of 200-800 µS. Only a few samples satisfied (Figure 4) the guideline necessity of standard worth making different examples unsuitable for utilization. This increase in conductance can be subjected to dissolved chemical effluent from industrial discharge.

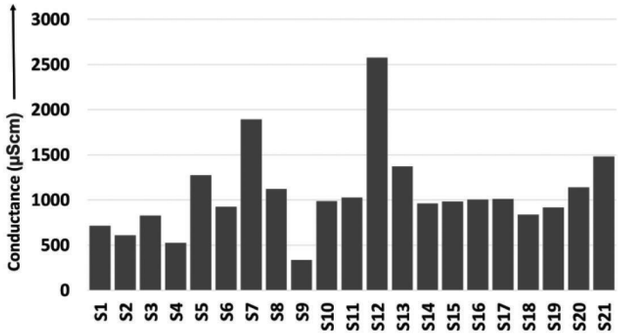


Figure 4: Conductance of various water samples.

Biochemical Oxygen Demand

The oxygen demand of water and wastewater is proportional to the amount of organic matter present. The BOD method measures the biodegradable carbon (carbonaceous demand) and, under certain circumstances, the biodegradable nitrogen (nitrogenous demand). The standard values recommended for BOD (Figure 5) lie between 3 and 5 ppm. Samples collected

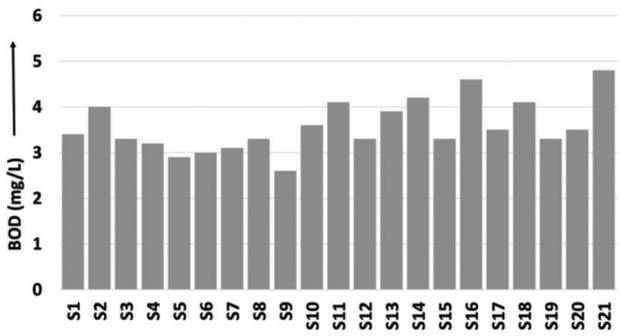


Figure 5: BOD of various water samples.

in the study area showed a great agreement with the standard values leading to water fit for consumption.

Heavy Metal-Estimation

The levels of metal ion contamination in water samples collected from various sample sites of the particular area in the study have been studied. The heavy metal concentration (Table 7) was determined with the help of standard literature procedures. The methods in their research work were quantified using AAS. The samples were acidified to 1% with nitric acid and then stored in the fridge till further analysis. The determination of (concentration of) heavy metals found in their research work were, Na, Mg, Ca, Cr, Cu, Zn, Cd, Pb. It has been found that as per recommended values by WHO, the content of Na and Mg was found to be higher in most of the samples. The high values of these two particular metal contents can be subjected to common salt chemicals used in the industries. Excess sodium can cause nausea, vomiting, convulsions, muscle twitching and rigidity, and cerebral and pulmonary oedema. High sodium levels in drinking water are connected to heart failure and salt intake. While an excess magnesium intake of magnesium salts may cause a change in bowel habits (diarrhoea). Drinking-water in with magnesium in high concentrations (~250 mg/L each) can have a laxative effect. The table below provides a comparison study analysis. However, traces of lead were identified in the sample but were below the limit. The water samples had no Cd or Hg.

Table 7: Metal-ions present in the water

	Mg	*Ca*	*Cu*	*Zn*	*Pb*	*Cd*	*Hg*
S1	1.134	48.223	0.048	0.712	0.000	0.000	0.000
S2	8.913	55.245	0.044	0.970	0.000	0.000	0.000
S3	7.125	73.689	0.039	2.034	0.024	0.000	0.000
S4	11.134	45.124	0.041	1.683	0.000	0.000	0.000
S5	14.156	39.824	0.052	1.038	0.046	0.000	0.000
S6	9.723	59.239	0.053	0.175	0.000	0.000	0.000
S7	8.239	62.429	0.038	0.182	0.012	0.000	0.000
S8	11.342	67.235	0.041	0.191	0.019	0.000	0.000
S9	13.142	72.243	0.039	1.035	0.034	0.000	0.000
S10	12.453	61.259	0.032	1.098	0.009	0.000	0.000
S11	8.234	59.249	0.025	2.012	0.013	0.000	0.000
S12	6.242	63.429	0.041	0.816	0.024	0.000	0.000
S13	8.232	71.349	0.055	1.041	0.018	0.000	0.000
S14	7.240	58.235	0.041	0.876	0.040	0.000	0.000
S15	5.424	66.244	0.057	0.714	0.017	0.000	0.000
S16	11.141	73.244	0.032	0.631	0.011	0.000	0.000
S17	12.535	52.260	0.029	1.075	0.009	0.000	0.000
S18	17.345	67.235	0.056	1.028	0.001	0.000	0.000
S19	14.250	70.239	0.053	1.014	0.015	0.000	0.000
S20	13.252	56.244	0.041	0.617	0.005	0.000	0.000
S21	12.424	49.243	0.028	1.035	0.002	0.000	0.000

Conclusion

In this study, information has been collected on the drinking water quality of the area in the study. An attempt was made to cover a wide range of areas for this study. Water samples from 21 different sites were collected. Samples have been analysed with various techniques. The interaction was also carried with few of the stakeholders main villagers and migrant workers. It gives an overview of the industrial region. Some of the parameters have shown slightly higher values than permissible limits and have been compared to the standard value recommended by organisations. Our study shows that water falls out of the standards of drinking quality and periodic estimation of the water quality is recommended for further usage. The massive industrialisation in the area has led to the migration from rural to urban areas leading to overpopulation and overcrowding beyond the carrying capacity. This, in turn, has a drastic impact on the health and sanitation facilities of the region due to congestion, poor health facilities and the development of the slum population. Thus, there is an urgent need to analyse the environmental impact of the industrial sector particularly in the context of Himachal Pradesh which lies in the fragile Himalayan belt.

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