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EVALUATION OF INDUSTRIAL EFFLUENTS AND SOIL PROPERTIES NEAR PHARMACEUTICAL COMPANIES OF HIMACHAL PRADESH (INDIA)

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ABSTRACT

There has been an increase in number of pharmaceutical companies in the present time. A large number of them are located in Himachal Pradesh. The effluents from these industries contaminate the nearby soil and water bodies. Here we analyses the treated waste water and soil from nearby areas for their physical, chemical and biological parameters. The samples were analyzed using standard methods according to WHO & APHA-AWWA-WPCF norms. The results showed a high amount of contamination. The pHs of the water samples showed contrasting features one being slightly alkaline while other highly acidic. The microbial activity was quiet low in the treated waste water while optimum amounts of bacterial and fungal activity was found in the soil samples near the industries. The presence of high amount of sodium and salinity was also observed. This could damage the crop productivity and soil fertility. There is an urgent need to propose strict restrictions on discharge of harmful effluents in the environment.

Key words: Industrial Effluents, Soil Properties, Pharmaceutical Companies, Himachal Pradesh

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1. INTRODUCTION

The undesirable changes in chemical, physical and biological characteristics of soil, water and air caused due to pollution that may destructively influence the life or make a potential wellbeing danger of any living beings. Water is an important environmental constituent for existence of life on earth. It has an important role in crop sustenance and productivity. Water assets have assumed basic part in the financial development of contemporary social orders.

In Indian societies productive use and powerful administration of water assets is very significant. However, informal administration and misuse of water assets constantly has made unfortunate issues as water logging, saltiness and contamination levels of disturbing points of confinement because of mining, enterprises and civil utilize. India with rural based economy utilizes water for water system inexhaustibly and its quality relies on sort and amount of broke down salts. Salts in the irrigation water appear from disintegration of gypsum, lime, etc. and weathering and disintegration of rocks and soil. Salts present in irrigation water are a threat especially in arid conditions as they affect crop yield and plant health. The salty irrigation water also effects the physical condition of the soil, life span and fertility (Ayers and Westcot, 1994).

Soil system also undergoes changes that are influenced by a number of environmental factors (Sharma, 2009). This is due to large amount of industrial wates containing harmful chemical that are dumped directly into the soil. This leads to loss of fertility and may cause ecological imbalance. The ideal agricultural production generally relies upon water and also soil quality (AlSalim and Matte, 2009).

The present study has been done to analyse the physical, chemical and biological parameter of industrial waste water and soil at pharmaceutical industries area in Nalagargh and Baddi districts of Himachal Pradesh. Himachal Pradesh is known area for pharmaceutical production companies. These companies produce various harmful chemical as waste materials and the effluents are directly dumped into the soil or river. This changes the pH and other properties of the soil. Here we have studied various parameter of treated waste water from the industries and the soil nearby to analyse their effect on ecology.

2. MATERIALS AND METHODS

The water and soil samples were collected from two areas of Baddi and Nalagarh region of Himachal Pradesh. The sample collection was done from the Pharmaceutical companies functioning in that area in 2016. The treated waste water was provided by the companies as the waste water is very harmful. The soil samples were collected from surroundings of companies and then packed in tight polybags and sent for analysis.

Standard methods for analysis of physiochemical parameters were used to analyse water and soil samples(APHA, 2005).In case of water samples, physical parameters used in the study were temperature, electrical conductivity (EC), salinity, pH, total solids (TS), total dissolved solids (TDS), colour, appearance, and odour. For analysis of chemical characteristics, total hardness, total alkalinity, chloride, Sulphate, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrogen, Sodium, Phosphorous, Calcium, Potassium, Organic Carbon, Cadmium, Cobalt, Nickel, Copper, Lead, Phosphate, Nitrate, Iron, and Sodium Absorption Ratio (SAR). Total bacterial count and Escherichia coli count was used to estimate biological parameters. Similarly for soil samples, physical parameters used in the study were PH (of 5% slurry), Bulk Density, Moisture, and Water Holding Capacity. Similarly chemical parameters were estimated using Electrical Conductivity, Salinity, Porosity, Alkalinity, Total Nitrogen (as N), Phosphate (as P), Sodium (as Na), Potassium (as K), C/N Ratio, Sulphate, Chloride, Calcium, and Magnesium. Total bacterial count, Escherichia coli count and total fungal count were used to estimate biological parameters. The samples were analyzed according to WHO & APHA-AWWA-WPCF norms (APHA, 2007, WHO, 2008).

3. RESULTS AND DISCUSSION

The parameters (physical, chemical and biological) were analyzed in the water and soil sample taken from of Baddi and Nalagarh region of Himachal Pradesh near some of Pharmaceutical companies in 2016. The area of sample collection is presented in Figure 1 and Table 1. The findings from both were analyzed and considerable differences were found.

Figure 1: Map showing the Nalahgarh and Baddi are in Himachal Pradesh

Table 1: Details of location of collection of soil and water samples

S.No.	Name of Industry	Location	Sample No./ Station No.
1.	Immcule Pharmaceutical	Nalagarh, Himachal Pradesh	Sample 1/ S1
2.	Acme Pharmaceutical	Baddi, Himachal Pradesh	Sample 2/ S2

3.1. Analysis of soil samples

In the two study stations, the value of pH from 5% of slurry was almost the same and in the range of 7. pH is an important measure of soil alkalinity and acidity to identify the chemical nature of soil. Since the temporal alteration in the pH are due to respiration, primary production, decomposition of organic matter and mineralization in the soil, it is a reflection of bio-geochemical processes in the soil at a given time (Behera, 2006). The moisture varied from 7.1% to 2.91% in sample 1 and 2 respectively, but the water holding capacity of the soil was 19.60% and 15.70% respectively in sample 1 and sample 2.There was an increase in moisture content in the soils of station 1 area. In addition to universal solvent and transporting agent, water also maintains the texture and compactness of the soil. Generally moisture in soil is due to infiltration of water from precipitation. The bulk density was 1.03 and 1.02 in the samples respectively. The unit volume of dry weight is defined as the bulk density. Usually, the soils that have high bulk density inhibit the penetration of root and have low infiltration and permeability (Saxena, 1998). Specific gravity of soil is directly related to its bulk density and may be used as an index of soil quality (Table 2).

Table 2: Physical parameters of soil samples from the study area.

Parameters	Sample 1	Sample 2
PH (of 5% slurry)	7.36	7.19
Bulk Density	1.03	1.02
Moisture	7.91%	2.91%
Water Holding Capacity	19.60%	15.70%

Table 3: Chemical parameters of soil samples from the study area.

Parameters	Sample 1	Sample 2
Electrical Conductivity (µs/cm)	671	464
Salinity (mg/kg)	40.3	27.2
Porosity	34%	32%
Alkalinity (mg/kg)	137.9	216.7
Total Nitrogen(as N) (mg/kg)	2860	2625
Phosphate(as P) (mg/kg)	39.06	42.01
Sodium (as Na) (mg/kg)	286.12	292.3
Potassium (as K) (mg/kg)	102.08	112.1
C/N Ratio	7.72	8.82
Sulphate (mg/kg)	35.2	75
Chloride (mg/kg)	177.3	68.98
Calcium (mg/kg)	41.2	57.07
Magnesium (mg/kg)	25	5.01

The electrical conductivity was recorded as 671 µs/cm at station 1 and 464 µs/cm and station 2 while the salinity was 40.3 mg/kg and 27.2 mg/g respectively at both stations. The electrical conductivity affects crop suitability, activity of soil microorganisms, crop yield, and plant nutrient availability. Soil health is indicated by the electrical conductivity. Soil salinity affects most or the plants adversely. In soil salinity, the most harmful ions are the sodium ions. The presence of sodium not only retards the plant growth but also effects crop yield and may even lead to death. In the present study, the sodium content of both the soils was quiet high. The basic constituent to all organic compounds are carbon and nitrogen. Carbon is related to energy flow and basis of photosynthesis. The total nitrogen indicates all the nitrogenous substances present in the soil in the form of nitrate, nitrite, ammonia etc. It is an essential element and important for plant growth. The total nitrogen present in the soil samples were 2680 mg/kg and 2625 mg/kg respectively while C/N ratio was 7.72 and 8.82 respectively. Mostly the chlorides that are present in soil are soluble in water (Trivedy and Goel, 1986). High chloride content of 177.3 mg/ kg was recorded in the soil sample at station 1. Calcium in soil is indicator soil fertility. It is needed for normal growth of plants. However other compounds present in the soil like nitrogen, phosphorus and potassium are good for plan growth and soil texture but sulphate is potentially harmful. The nitrogen, phosphorus and potassium were present in optimum quantities. The sulphate present in the soil was higher at station 2. The sulphates oxidise the sulphide compounds to sulphuric acid that lead to leaching of toxic metals ions like iron, lead, aluminium, cadmium etc (Dent, 1986). The metals inhibit the enzymatic activities.

Table 4: Biological parameters of soil of the study area.

Parameters	Sample 1	Sample 2
Total Bacterial Count (cfu/gm)	$5x10^6$	$4.9x10^6$
Total Fungal Count (cfu/gm)	$4x10^4$	$3.4x10^4$
E.Coli	Absent	Absent

The metabolic reactions from the microbial fauna and flora in the soil determine the microbial activity (Nannipieri et al 1990). The microbes present in the soil are responsible for mineralization and decomposition of animal and plant residues in the soil and therefore are the ecological indicators (Brookes, 1995). In the present study we found that sample 1 had 5x 106cfu/gm bacterial count and 4x 104cfu/gm fungal count while, sample 2 had 4.9x106 cfu/gm and 3.4x104cfu/gm bacterial and fungal count respectively. Escherichia coli were absent in both the samples. It has been evidenced from previous studies that enzyme activities and microbes are sensitive to contamination form heavy metals (Chen et al, 2005).

3.2. Analysis of water samples

The analysis of physical parameters showed that there was a great difference in the pH of the water samples (8.3 and 3.9) falling in acidic and basic range. This difference in waste water may be due to the type of products being manufactured in the companies. The electrical conductivity of both samples was high 1693 S/m and 1562 S/m showing the presence of huge amount of ions. The sample was colourless, clear and odour was agreeable. The salinity was below detection limits, and 1302 mg/L and 1198 mg/l total solids were present respectively. Total dissolved solids comprised mainly of chlorides, sulphates, carbonates, phosphates and nitrates of calcium, potassium, sodium, cadmium, cobalt, nickel, copper, lead and Iron. The amount of total dissolved solids was 1294 mg/L and 1192 mg/L (Table 5).

Table 5: Physical Parameters of water samples

Parameters	Sample 1	Sample 2
Temperature (^{0}C)	29.8	29.9
Electrical conductivity (EC) (S/m)	1693	1562
Salinity	Below detection limit	Below Detection Limit
pH	8.3	3.91
Total solids (TS) (mg/L)	1302	1198
Total dissolved solids (TDS) (mg/L)	1294	1192
Colour	Colourless	Colourless
Appearance	Clear	Clear
Odour	Agreeable	Agreeable
Alkalinity	205	Below Detection Limit

The presence of salts in the waste water contributed to 436 mg/L and 317 mg/L of hardness respectively in both samples and 205 mg/L of alkalinity in one sample (Table 5 and 6). The level of alkalinity in the other sample was below detection limits as also determined by the pH of the sample. Hardness of water is important in determining the suitability for industrial and domestic purpose. The present study showed that the tested waste water samples were in very hard category (Table 6).

Table 6: Durfor and Becker's Classification of the water sample based on total hardness

S.No.	Water Classes	Hardness	Range
1.	Soft	0 - 60	
2.	Moderately Hard	61 - 120	
3.	Hard	121 - 180	
4.	Very Hard	>180	S1 and S2 (463, 317)

The best measure for sodium (alkali) hazard is Sodium absorption ratio (SAR). SAR of water is directly related to absorption to sodium in the soil. It is used to determine the suitability of water for irrigation. If the concentration of sodium in higher in comparison to magnesium and calcium, it may retard the supply of water for crops, reducing soil permeability and deteriorating its characteristics. SAR is the measure for the proportion of sodium to calcium and magnesium. SAR can be computed by the following formula.

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

In our study, the samples of waste water from both the companies were of excellent category as shown in Table 7

Table 7: Classificaion of water samples based on SAR values Todd (1959)

Water Classes	**SARValues**	**Sodium Hazard Class**	**Range**
Excellent	<10	S1	6.34, 4.63
Good	10 to 18	S2	
Doubtful	19 -26	S3	
Unsuitable	> 26	S4 & S5	

Although the according to the SAR values the samples were of excellent category, yet their sodium hazard class was doubtful (Table 8). Salinity hazard is determined using the electrical conductivity.

Table 8: Class of Salinity Hazard

Salinity Hazard Class	EC in	Quality	Sample
C1	100- 250	Excellent	
C2	250 - 750	Good	
C3	750 - 2250	Doubtful	S1 & S2 (1693 S/m and 1562 S/m)
C4 & C5	> 2250	Unsuitable	

Table 9: Chemical parameters for water sample analysis

Parameters	Sample 1	Sample 2
Dissolved Oxygen (DO) (mg/L)	6.8	6.7
Biological Oxygen Demand (BOD) (mg/L)	<5	<5

Chemical Oxygen Demand (COD) (mg/L)	17	10
Chloride (mg/L)	379	73
Sulphate (mg/L)	Below detection limit	Below detection limit
Nitrogen (mg/L)	2	1.87
Sodium (mg/L)	304.7	188.8
Phosphorous (mg/L)	0.92	1.095
Calcium (mg/L)	143	Below detection limit
Potassium (mg/L)	21.52	Below detection limit
Organic Carbon (mg/L)	0.035	0.038
Cadmium (mg/L)	Below detection limit	Below detection limit
Cobalt (mg/L)	Below detection limit	Below detection limit
Nickel (mg/L)	Below detection limit	Below detection limit
Copper (mg/L)	Below detection limit	Below detection limit
Lead (mg/L)	Below detection limit	Below detection limit
Phosphate (mg/L)	0.92	0.7
Nitrate (mg/L)	0.7	0.17
Iron (mg/L)	Below detection limit	0.022

The chemical analysis revealed the presence of high amount of sodium in the samples and comparatively low amount of potassium and calcium. The calcium and potassium were below detection limits in sample 2. However heavy metals were below detection limits in the water samples tested. This may be because treated waste water was supplied by the company. The Biological oxygen demand (BOD) was less than five in both sample and chemical oxygen demand was 17mg/ml and 10 mg/ml respectively for both the samples. These values were under the permissible range for drinking water under Indian Standards for Drinking Water Specification (IS 10500:1991) (Table 9).

Table10: Biological Parameter of water sample

Parameters	Sample 1	Sample 2
Total bacterial count (Cfu/ml)	710	42
E. coli. Count (MPN/100ml)	Not detected	Not detected

The bacterial counts were 710 Cfu/ml and 42 Cfu/ml respectively in sample 1 and sample 2, while Escherichia coliwere not detected in the samples.

4. CONCLUSION

The process of industrialization and urbanization leads to the generation of problems of local and regional environment, adversely affecting the quality of life. The rapid growth of population technological advancements and industrial boom has brought enormous problems and degradation of environment. The inorganic and organic substances present in the industrial wastes affect various soil characteristics like mineral strength and pH. The change in pH makes the soil acidic or alkaline. Increased acidity mobilizes heavy metals like Al, Cd, Zn, Hg, Mn, and Fe which inturn may affect the flora and fauna of the area to a great extent. Though the modern world cannot do without industrial growth, it should not be at the expense of nature and natural resources.

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