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Effect of Industrial Effluents on Ecophysiological Properties of Plants of Bhilai Industrial Area, India

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Study Area: Raipur & Durg, Chhattisgarh India

Coordinates: 20°54' to 21°32'N; 81°10' to 81°36'E & 22°33' to 21°14'N; 82°06' to 81°38'E

Key words: Floral diversity, Regional flora, Soil texture

Abstract

The pollutants of industries often alter the existing biodiversity of that particular area. Contamination of soil occurred due to the release of hydrocarbons, pesticides and other metals in the soil reduce plant metabolism and crop yield. The present work was undertaken to evaluate the effect of industrial effluent on growth pattern and ecophysiological properties of the plants existing around Bhilai industrial area. During the fieldwork, soil samples were collected from the study areas for analysis of different soil parameters. Frequency, relative frequency, density, relative density, abundance, plant cover, basal area and relative dominance of each species were calculated by a standard quadrat method. Regional floras were used for the identification of plants. The dominant plant species were carefully recorded in all the four zones of study area. The study of species diversity would be helpful in understanding community composition, structure, change, and development as species diversity is regulated by the environmental factors.

Introduction:

Pollution study in industrial units has been aimed by many researchers. Usually, Industries discharge their wastes into water and on land without any treatment or after partial treatment (Jolly *et al.*, 2012). Indeed, the untreated or partially treated effluent enters in a water body either gets dissolved or lies in a suspended form on the main water bodies, thereby causing the aquatic pollution. Indian cities are being exposed to high levels of air pollution and people living in these cities are paying a price for the deterioration in air quality. Agricultural crops can be effected when exposed to high concentrations of various air pollutants (Gupta, 2016). Damages range from visible markings on the foliage, reduced growth and yield to the premature death of the plant (Bolan & Hedley, 2003). The pollutants can also cause a serious threat to the overall physiology of plants. Any disturbance in the soil ecosystem can disturb the microbial activity and thereby affecting the availability of nutrients and thus affecting the vegetation type of that particular area. The soybean crop was also observed to have the adverse effects of textile dye (Ravi *et al.*, 2014). Thus, the present study was taken into consideration to study the soil of industrial area and its ecophysiological effect on the plants of Bhilai industrial area.

Since ancient times, state Chhattisgarh of India is famous for its natural resources, tribes and rich biodiversity. The state is endowed with 44% of forest cover. A large size of the human population resides in forest and villages. Plants play important role in their life particularly in dialects, socio-religious ceremonies, a traditional and domestic system of medicine.

Methodology:

Study area: district Durg and Raipur both are adjacent to each other. Durg is somewhat situated in the southern part of the rich Chhattisgarh plain with forests covers of 2,238 km². It has heavy to deep soils, which have high water retention capacity due to high clay content. These soils have better nutrient value and are suitable for paddy cultivation. However, Raipur district is situated in the fertile plains of Chhattisgarh Region. The climate of both the districts is a tropical type, mainly dry and hot.

For current study the area was divided into four zones;

- Bhilai Industrial Area, Zone I
- Bhilai Steel Plant, Zone II
- Chalkatta Bhilai Area, Zone III
- Botanical Garden, NPG College of Science, Raipur (control)

Each of the four zones was further divided into 10 study sites. The study area was divided on the basis of diversity, distribution, structure of communities and soil conditions.

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Soil analysis: the soil samples were collected with simple crew auger according to the method adopted by Taylor *et al.*, (1998); Maiti (2003). Soil from four study zones; i) Bhilai Industrial Area, ii) Bhilai Steel Plant, iii) Chunkatta Bhilai Area & iv) Botanical Garden, Govt. NPG College of Science, Raipur was collected from 0-30 cm depth. Soil samples were collected randomly from ten same places each from four study sites yearly from July 2012 to June 2015. Collected samples were stored in labeled polyethylene bags and brought to the laboratory. At each spot, surface litter was scraped and vegetation cover was removed before the collection samples. Total 1 kg soil sample was taken for laboratory analysis. The soil samples from the same study site and same layer were mixed thoroughly, air dried, lightly crushed and passed through a 2 mm mesh sieve to remove the stone pieces and large root particles. The composite soil samples were used for detail analysis.

Coarse Texture was analyzed by sieving method: American Society for Testing and Materials (ASTM) method were used for the separation of sand silt and clay respectively (Gee & Bauder, 1986).

Water Holding Capacity (WHC): WHC was measured by Porous Pot Method. The moisture content of the soil was determined by oven-dry method (Allen *et al.*, 1974) and calculated by following formula-

$$\text{Water holding capacity} = \frac{\text{Amount of water in soil}}{\text{Weight of oven dry soil}} \times 100$$

Soil Organic Matters: it was calculated by manual potentiometric titration method given by (Allison *et al.*, 1965; Bartlett, 1994; McLeod, 1975).

Carbon content and organic matter were determined by the following formula:

$$\text{Carbon}(\%) = 3.951/S(1-T/S);$$

$$\text{Organic matter}(\%) = \% C \times 1.724$$

Where, g = weight of the sample in gram,

S = ml to the ferrous solution with blank titration

T = ml of ferrous solution with example titration.

Total Soluble Salt was measured by Conductivity Meter: Total soluble salt was measured by conductivity meter and data was expressed as μ Mole (Richards, 1954).

Soil pH: soil pH was measured by Electrode method, APHA 21st edition (Digital pH meter; Systronics, 335).

Phytosociological survey: the plants and data were collected from Durg and its neighboring areas; Bhilai Industrial area, Bhilai Steel Plant, Chunkatta Bhilai Area and Botanical garden of Govt. NPG College of Science, Raipur. Quadrates were placed at randomly and mean value was recorded. The phytosociological survey was done for the two years, i.e., July from 2013 to June 2015. The study of plant diversity and community structure were conducted. Plant identification was done with the help of literatures available on the regional floras

Plant Community Study: Frequency, Relative Frequency, Density, Relative Density, Abundance, Plant Cover, Basal Area, Relative Dominance and Important Value Index were calculated as per the method prescribed by Curtis & McIntosh (1950). Graphs were plotted using the recorded data by the prescribed method. Total 10 quadrats were studied in each study area.

Results :

The results of Coarse texture (percentage) for the four studied zones in ten sites of Durg and Raipur districts are presented in Table-1.

The highest recorded sand amount was 62 %, while the lowest was 19 % and both were from the Bhilai Industrial plant areas.

Table-1: Coarse texture (%); sand, slits, clay from four study zones (10 sites) of Durg & Raipur districts.

Sites	Zone-I			Zone-II			Zone-III			Control		
	Sd.	Sl.	Cl.	Sd.	Sl.	Cl.	Sd.	Sl.	Cl.	Sd.	Sl.	Cl.
S-1.	40	35	25	40	35	25	28	25	47	28	47	25
S- 2.	32	40	28	38	32	30	45	30	25	40	35	25
S- 3.	33	42	25	31	32	37	25	43	32	42	35	25
S- 4.	62	20	18	28	33	39	48	34	18	28	26	46
S- 5.	47	25	28	28	34	38	41	38	21	40	36	24
S- 6.	24	45	31	55	18	27	28	45	27	50	25	25
S- 7.	25	40	35	42	28	30	33	36	31	30	28	44
S- 8.	49	26	25	39	34	27	29	45	26	48	27	25
S- 9.	32	38	30	44	33	23	33	35	32	38	36	26
S- 10.	19	55	26	40	28	32	35	42	23	29	28	43
Ave.*	36.3	36.6	27.1	38.5	30.7	30.8	34.5	37.3	28.2	37.3	32.3	30.8

Sd.-Sand; Sl.-Slit; Cl.- Clay; *-Average

The results of water Holding Capacity (%) of four study zones in ten sites of Durg and Raipur districts are presented in Table-2.

The water holding capacity was observed to be highest in 24 hours was 38 % from the NPG College's Botanical garden (control), while the lowest 26% from Bhilai steel plant area. However, the highest and lowest percentages were reported to be very close to each other.

Table-2: Water Holding Capacity (%) of four study zones (10 sites) of Durg and Raipur district, after 3 distinct time gaps

Sites	Zone-I			Zone-II			Zone-III			Control		
	24h	26h	28h	24h	26h	28h	24h	26h	28h	24h	26h	28h
S-1.	28.6	26	25	31	29	27.5	34	31.5	29	35	33	31
S- 2.	35	34	33	28	26.5	25	29	28	26.5	38	35	33
S- 3.	31	30	30	29	28	26.5	33	31.5	29	36	35	34
S- 4.	29.5	29	28	32.5	29	28	32	29	27.5	32	30	29
S- 5.	30	28	27	34	31	29.5	32	28.5	26	33	32	30
S- 6.	28	26	25	26	25.5	24	34	32	29.5	28	27	25
S- 7.	29	27	26	33	30.5	28	30	27.5	26	37	35	33
S- 8.	33	31	30	29.5	27	26	35	32.5	30	28	27	25
S- 9.	32	30	29	29	26.5	25	30	27	25.5	27	26	23
S- 10.	30	29	29	31	29	27.5	29	28	26.5	30	28	26
Ave.*	30.61	29	28.2	30.3	28.2	26.7	31.8	29.55	27.55	32.4	30.8	28.9

*-Average; h-hours

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The results of organic matter CaCO_3 (kg/ha) of four study zones in ten sites of Durg and Raipur district are presented in the Table-3.

The highest organic matter 35 kg/ha was reported from the Chunkatta Bhilai, whereas the lowest 9.5 kg/ha was evidenced from Bhilai steel plant area.

Table-3: Organic matter CaCO_3 (kg/ha) of four study zones (10 sites) of Durg and Raipur district

Sites	Zone-I	Zone-II	Zone-III	Control
Site 1.	15.2	14.0	16	27.5
Site 2.	18.5	29.3	32	14.0
Site 3.	14.0	18.0	29.3	29.5
Site 4.	20.7	27.5	22.8	10.0
Site 5.	23.2	25.8	22	29.3
Site 6.	11.5	10.5	27.5	10.2
Site 7.	24.8	9.5	18.8	25.8
Site 8.	22.0	22.8	35	27.5
Site 9.	16.7	35.8	33	19.7
Site 10.	18.8	18.8	10.5	22.0
Average	18.54	21.2	24.69	21.55

The results soluble salt (EC) (dS/m) of four study zones in ten sites of Durg and Raipur districts are presented in Table-4.

The maximum average value was evidenced from 0.501 dS/m the control area, Botanical Garden, NPG college of science, Raipur, whereas the Bhilai Steel Plant area showed the lowest average value of soluble salt 0.268 dS/m.

Table-4: Soluble Salt (EC) (dS/m) of four study zones (10 sites) of Durg and Raipur district

Sites	Zone-I	Zone-II	Zone-III	Control
Site 1.	0.12	0.18	0.14	0.24
Site 2.	0.87	0.10	0.07	0.05
Site 3.	0.34	0.7	0.36	0.35
Site 4.	0.13	0.4	0.27	0.46
Site 5.	0.07	0.15	0.34	0.73
Site 6.	0.05	0.13	0.57	0.62
Site 7.	0.22	0.21	0.37	0.53
Site 8.	0.56	0.32	0.26	0.71
Site 9.	0.74	0.14	0.34	0.86
Site 10.	0.23	0.35	0.41	0.46
Average	0.333	0.268	0.313	0.501

Table-5: Soil Analysis pH (1:5 ratios) of four study zones (10 sites) of Durg and Raipur district

Sites	Zone-I	Zone-II	Zone-III	Control
Site 1.	7.8	7.9	8.7	7.13
Site 2.	8.1	8.0	8.0	7.0
Site 3.	7.4	8.1	7.2	6.89
Site 4.	8.0	8.1	8.2	7.36
Site 5.	7.9	8.3	8.1	6.11
Site 6.	8.1	7.2	8.2	7.84
Site 7.	7.3	7.2	7.9	7.78
Site 8.	7.8	8.2	9.1	6.13
Site 9.	7.9	6.8	7.3	7.92
Site 10.	8.4	6.2	8.2	6.55
Average	7.87	7.6	8.09	7.071

The results of soil Analysis pH (1:5 ratios) of four study zones in ten sites of Drug and Raipur districts are presented in the Table-5.

The highest average pH value was from Chunkatta Bhilai area i.e., 8.09 and the lowest average, 7.071 was from the control area Botanical garden of NPG college, Raipur.

Total 92 plant species were recorded, belonging to 29 families and 82 genera of angiosperms. The number of plants species reported in Zone-I were 47, 41 were reported in Zone-II, 43 were reported in Zone-III and 44 were reported in Zone IV (control).

Important Value Indexes (IVI): the natural vegetation of the study site showed rich biodiversity in all the study areas. Grass species were dominant according to total importance value index around the four study sites. The final abstraction of phytosociological behavior in the form of their importance value indices revealed that maximum IVI was of *C. spachelatus* Rottb, *Lactuca serriola* L., *Cynodon dactylon* L. Fig.- 1 to 4.

Figure-1: Graph showing the Important value index of plants in Zone-I (Bhilai Industrial Area of Durg district). Max. value - *Cynodon dactylon*- 12.1, Min. value- *Portulaca oleracea*- 1.22

Figure-2: Graph showing the Important value index of plants in Zone-II (Bhilai Steel Plant area of Durg district). Max. value- *Cyperus spachelatus*- 1.22, Min. value- *Pergularia daemia*- 2.22, *Aeschynomene americana*- 2.22

Figure-3: Graph showing the Important value index of plants in Zone-III (Chunkatta Bhilai Area of Durg district).
Max. value- *Cynodon dactylon*- 14.3, Min. value- *Ageratum conyzoides*-1.73

Figure-4: Graph showing the Important value index of plants in Zone-IV (Botanical garden for control, Govt. NPG College of Science, Raipur, district Raipur).
Max. value- *Cynodon dactylon* - 15.21; Min.value-*Mimosa pudica*-2.15

Discussion :

In present study 92 species, 82 genus from 29 families of the plants were identified of industrial area of Durg and Raipur district of Chhattisgarh state, in the fields surveyed. Some plant species were found throughout the year viz., *Corton oblongifolia*, *Datura alba*, *Mimosa pudica*, *Parthenium hysterophorus*, *Astracantha longifolia*, *Alysicarpus tugosus*, *Solanum nigrum*, *Ipomea carnea*, *Tridax procumbance*, *Ageratum conyzoides*, *Calotropis procera*, they remain protected by the grazers due to pungent smell and rough leaf surface (Thirunarayanan, 2013). The plant species which were commonly found in study area were *Cynodon dactylon*, *Eragrostis viscosa*, *Eleusine indica*, *Euphorbia hirta*, *Centella asiatica*, *Convolvulus nummularius*, and *Parthenium hysterophorus*. Irrespective to the microhabitats, the plant species e.g. *Cynodon dactylon*, *Achyranthes aspera*, *Alternanthera sessilis*, *Melilotus indica*, *Alysicarpus vaginalis*, *Cynodon dactylon*, *Cyperus sphacelatus*, *Parthenium hysterophorus*,

Linnaea borealis, *Ageratum conyzoides*, *Convolvulus arvensis*, *Cassia tora*, *Desmodium trifolium*, *Coix aquatica*, *Roxb*, *Indigofera linifolia*, *Euphorbia hirta*, *Sida cardifolia*, *Lactuca serriola*, *Tridax procumbance*, and *Heliotropium indicum* were recorded as dominant species throughout the study area. These species are cosmopolitan because they perform remarkable range of adaptability to varied ecological conditions. Similar studies were also done by Oudtshoorn (1999); Dahlberg (2000); Adhikari *et al.* (2003); Thirunarayanan (2013); Thakur & Khare (2009), Silva, (2006). The dominant plant communities were correlated with soil conditions. The highest number of plants belonged to families of Dicotyledons they were especially from Acanthaceae, Asteraceae, Malvaceae, Fabaceae, Lamiaceae, Chenopodiaceae, Solanaceae, Amaranthaceae Verbenaceae and Euphorbiaceae etc. The weeds belonging to Monocotyledons species were Poaceae, Cyperaceae of which *Cynodon* and *Cyperus* species were in dominating state. Our results resemble with Rodrigues *et.al.* (2018), where the association of the structure and diversity of plant communities with physiochemical characteristic of soil in the Caatinga domain at the transition to Cerrado in Brazil. Chafjiri *et.al.* (2016), observed the distribution of plant species and their relation to soil properties in protected and degraded stands of *Quercus macranthera* in Northern Iran.

Our study was based on the frequency, relative frequency, density, relative density, abundance, relative dominance or plant cover, basal area of the area. *Astracantha longifolia*, *D. alba*, *I. linnaei*, *O. basilicum*, *A. aspera*, *A. maxicana*, *L. serriola*, *M. pudica*, *P. hysterophorus* etc. were found as a dominant species at the polluted areas.

The natural vegetation of study site showed rich biodiversity in all the study area. Grass species were found to be dominant according to total importance value index in all the four study sites. The plant species which showed low relative frequency were *A. vaginalis*, *B. alba*, *B. diffusa*, *C. procera*, *D. alba*, *C. gigantia*, *A. americana*, *A. conyzoides* and *J. curcas*. Grass species; *C. sphacelatus*, and *Lactuca serriola* *Cynodon dactylon* were dominant according to total importance value index around the four study sites they played an important role in the structure and dominance in the phytodiversity. Finally, it could be concluded that species diversity is affected by multi-environmental factors. Soil Coarse texture, Water Holding Capacity, Soil Organic Matters, total Soluble Salt, and Soil pH were major factors for plant diversity similar conclusions were given by Wang *et.al.* (2016). They studied the effects of the soil factors on vegetation restoration and they reported that the effects of the soil factors were higher than those of the topographic factors.

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