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International Journal of Current Research
Vol. 7, Issue, 11, pp.22271-22277, November, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

STUDY ON THE PHYSICOCHEMICAL PROPERTIES OF SOIL AND PHYTOSOCIOLGICAL ASPECTS OF PLANTS IN AN INDUSTRIAL HUB OF KERALA

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ARTICLE INFO

Article History:
Received 29th August, 2015
Received in revised form
18th September, 2015
Accepted 08th October, 2015
Published online 30th November, 2015

Key words:
Eloor,
River Periyar ,
Pathalam Bund,
Pollution,
Soil,
Phytosociology

ABSTRACT

The present work aimed at analyzing the pollution extent of Eloor, an important industrial hub of Kerala. The study targeted at analyzing the impact of industrial pollutants on the physicochemical soil properties and the plant diversity of the site. The site selected for the purpose was Pathalam Bund zone of Eloor. The chemical analysis revealed that the pH of the polluted sample was alkaline while it was neutral in case of control sample. The polluted soil sample carried more chemical load like sulphate, chloride, phosphate, magnesium, calcium. The percentage of organic matter was found to be less in polluted sample. The plant community study proved that the plant diversity of the polluted zone was evidently lesser than the control.

***Citation*:** Alka Nassar, Liza Jacob and Romilly Margaret Mendez, 2015. "Study on the physicochemical properties of soil and phytosociolgical aspects of plants in an industrial hub of Kerala", *International Journal of Current Research*, 7, (11), 22271-22277.

INTRODUCTION

Pollution is any change which has the potentiality to adversely affect the biological and non-biological equilibrium of the environment. The vast injudicious use and exploitation of various types of chemicals have polluted the soil, water and air so much so that the biodiversity is greatly threatened. The present work aimed at analyzing the impact of industrial pollution on the soil. The site selected for the same is Eloor, an important industrial zone of Kerala. It is an island situated on the banks of River Periyar around 17 kilometers from its mouth at the Arabian Sea near the city of Cochin, the commercial capital of Kerala. It occupies an area of 11.21 square kilometers. Eloor supports the largest industrial belt in Kerala with over 247 chemical industries. These industries make a range of chemicals like petrochemical products, pesticides, rare-earth elements, rubber processing chemicals, fertilizers, zinc or chromium products and leather products. There are about 250 industries operating actively on either sides of River Periyar.

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The industries take in large amounts of fresh-water from the river and in-turn discharge concentrated effluent with nominal treatment.

MATERIALS AND METHODS

To study the impact of industrial pollutants, samples were collected from both aquatic (bottom of River Periyar) and terrestrial soil habitats of Eloor industrial area. The control samples were collected from Desom, a nearby village.

Soil Analysis

Chemical analysis of soil

Preparation of soil samples for analysis

The soil samples collected from the polluted and the control sites were allowed to shade dry for about 48 hours. After the soil was shade dried the large stones, pebbles and other unwanted remains were removed from it. After this process the clumped soil pieces are also crushed well. This soil sample was used for further analysis.

Estimation of soil pH

To determine the pH of the soil, soil suspension was prepared by mixing soil and water in the ratio 1:2. Ten gram of preweighed soil was put in a 50 ml beaker and 20 ml of distilled water was added into the soil. It was shaken well by placing in a rotary shaker for 30 minutes. The accurate pH was measured electrometrically using pH meter.

Estimation of Organic matter

Five gram of well dried soil was weighed and transferred into a clean 500 ml conical flask. Added 10 ml of 1 normal Potassium dichromate ($K_2Cr_2O_7$) and 20 ml of conc. Sulphuric acid (H_2SO_4) having silver sulphate dissolved in it, and mixed well by gentle swirling. Allowed to stand the flask for about 30 minutes, and when the reaction was over, diluted the contents using 200 ml of distilled water. Ten mille liter of phosphoric acid and 1ml of diphenylamine indicator were added into it. The colour changed to bluish purple. Titrated the contents with ferrous ammonium sulphate taken in a burette until the blue colour changed to brilliant green.

Calculation

% Carbon = $v1 - v2/w$ x 0.003 x 100
% Organic matter = % C x 1.724
Where $v1$= volume of $K_2Cr_2O_7$ (10 ml)
$v2$ = volume of ferrous ammonium sulphate
W = weight of the soil taken

Estimation of Sulphate

A preweighed 20 g of well dried soil was mixed with 100 ml of distilled water and was placed in a rotary shaker for 2 hours for complete dissolution of ions. After filtration the filtrate of each sample was subjected to estimation of sulphate. Hundred mille liter of sample was taken in a 250 ml conical flask. Five mille liter of conditioning reagent was added to it. Stirred the sample on a magnetic stirrer and during stirring added a spoonful of Barium Chloride crystals. After the addition of Barium Chloride crystals it was stirred only for one minute. When the stirring was over, the optical density was read on a spectrophotometer at 420 nm. The concentration of sulphate was found out from the standard curve.

Estimation of Chloride

Chloride content of the soil sample was determined by Mohr's method (Argentometric titration method). Weighed 10 g of soil and it was mixed with 50 ml of distilled water and placed in a rotary shaker for 2 hours for complete dissolution chloride of ions. Fifty ml of filtered sample was taken in a conical flask and added 2ml of potassium chromate (K_2CrO_4) solution into it. Titrated the content against 0.02 N Silver nitrate ($AgNO_3$) until a persistent reddish brown tinge appeared.

Calculation

% chloride = (ml x N) of $AgNO_3$ x 35.5/ml soil solution x 2

Estimation of Alkalinity

Prepared 1:5 soil suspension by shaking 20 g of soil with 100 ml of distilled water in a 250 ml conical flask for about 2 hours. After that the suspension was filtered out. 100 ml of this soil solution was taken in a conical flask, added 2-3 drops of phenolphthalein indicator in it. If the solution remained colourless, the phenolphthalein alkalinity (PA) is zero and total alkalinity was analyzed by adding 2-3 drops of methyl orange indicator, at the end point the yellow colour changed to pink. If a pink colouration was observed after addition of phenolphthalein indicator then it was titrated with 0.1 N HCl until the colour disappeared at the end point.

Calculation

Total alkalinity, mg/100g = (ml x N) of HCl x 500 / ml soil solution

Estimation of calcium

Twenty five gram of air dried soil was weighed out in a conical flask. Added 50 ml of Ammonium Acetate solution into it. Stirred the suspension well by placing in a shaker for 2 hours and placed it overnight. Later the suspension was filtered and the soil was washed 4-5 more times with ammonium acetate solution. Finally the volume of the filtrate was made up to 250 ml with distilled water. Fifty ml of the sample was taken in a conical flask. Added 2 ml of NaOH solution and a pinch of murexide indicator into the sample; a pink colour developed. Titrated the content with EDTA solution until changed to dark purple.

Calculation

% Calcium = A x 400.8 x V /v x10000 xS
Calcium, mg/100 g =A x 400.8xV / v x 20.04 x 10 x S

Where,

A = volume of EDTA (ml) used for calcium determination
B = volume of EDTA (ml) used for calcium determination
V = total volume of soil extract prepared
S = weight of soil taken
v = volume of soil extract titrated

Estimation of Magnesium

Amount of magnesium in the soil was determined as the difference between calcium plus magnesium titration and the titration alone for calcium. Calcium plus magnesium titration was done by taking 50 ml of ammonium acetate solution in a conical flask. Added 1 ml of buffer solution into it. If the sample was having higher amount of heavy metals, added 1 ml of Na_2S solution. Added a little of Eriochrome Black T indicator, the solution would turn wine red. Titrated the contents with EDTA solution; the colour changed to blue at the end point.

Calculation

% Magnesium = (B-A) x400.8 xV / v x 10000 xSx1.645
Magnesium, mg /100 g = (B –A) x400.8 xV/vx10xSx1.645x12.16

Where,

A = volume of EDTA (ml) used for calcium determination
B = volume of EDTA (ml) used for calcium determination
V = total volume of soil extract prepared
S = weight of soil taken
v = volume of soil extract titrated

Estimation of Phosphorous

Weighed out 1.0 g of air dried soil and added 200 ml of 0.002 N H_2SO_4, the suspension was shaken at least for 1 hour in a shaker, filtered through a filter paper to get a clear solution. Fifty ml of the sample was taken in a conical flask. Then added 2ml of ammonium molybdate solution and five drops of stannous chloride reagent into it. A blue colour appeared in the presence of phosphate. The optical density was read at 690 nm on a spectrophotometer using distilled water as the blank with the same amount of chemicals. Reading was taken after 5 minutes but before 12 minutes of the addition of the last reagent. Later the concentration of phosphate was found out by preparing the standard curve.

Phytosociology

The sociological ordering of plants in a community cannot be studied by simple observation of the plant species. So such an analysis can be made only by viewing the plant species at different sample areas in the habitat. The polluted site selected for the same was Pathalam Bund area of Eloor and the control zone was Desom, near Aluva. Both these sites are the two extreme ends of river Periyar.

Quadrat Method

To study the plant community of Eloor, square sample plots were used. They were randomly placed on the area and the studies were carried out. To characterize the community certain parameters were used like density, frequency, importance value index *etc.*

Density

It is the numerical strength of a species in relation to a definite unit space.

Density of species per unit area =

Total no. of individuals of a species in all the sample plots
Total no. of sample plots studied

Total no of quadrats in which the species occurred x 100
Total number of quadrats studied

Frequency

It refers to the degree of dispersion in terms of percentage occurrence.
Frequency of a species per unit area =

Total no of quadrats in which the species occurred x 100
Total number of quadrats studied

Relative frequency of a species = Frequency of species in a stand x 100
Sum of the frequencies for all species

Abundance

Abundance of a species = Total number of individuals of the species in all quadrats
Total no. of quadrats in which the species occurred

Total no. of quadrats in which the species occurred

Importance value index (IVI)

In a heterogeneous community the complete picture of a species in relation to the community structure can be obtained by adding the values of relative density, relative dominance and relative frequency. This total out of 300 is called Importance Value Index (IVI) of the species.

Importance value index =

Relative density (RD) + Relative dominance (RDo) + Relative frequency (RF)

RESULTS

The pH of the polluted wet and dry sample were 8.1(alkaline) and 8.49(alkaline) respectively, whereas both the wet and dry control sample showed a neutral pH i.e. pH 7(Table 1 and 2).

Table 1. Properties of Soil from River Periyar bottom

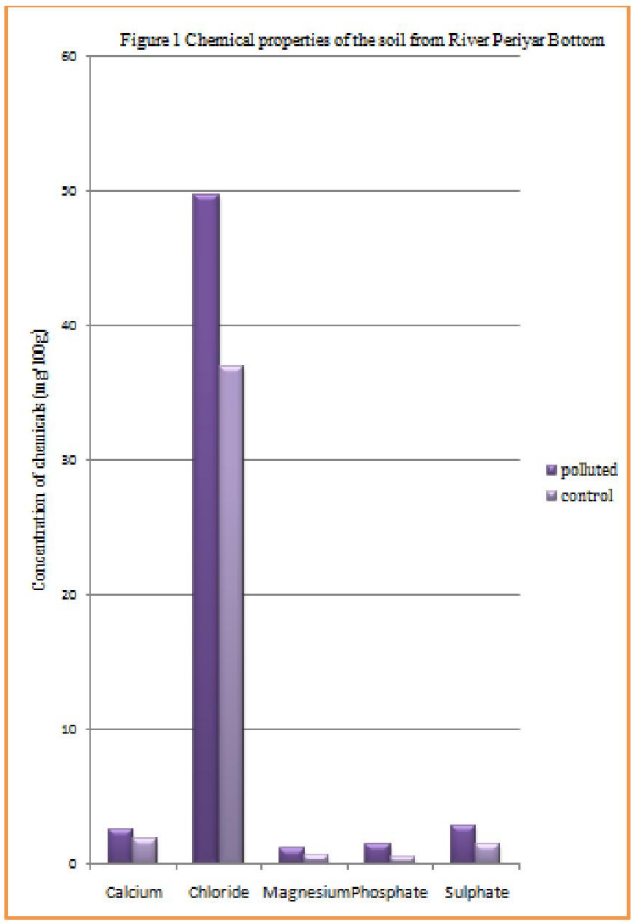
Sl. No.	Tests	Polluted Site (Mg/100g)	Control Site (Mg/100g)
1.	P^H	8.1	7
2.	Alkalinity	1.5	0.7
3.	Organic matter	0.13	0.56

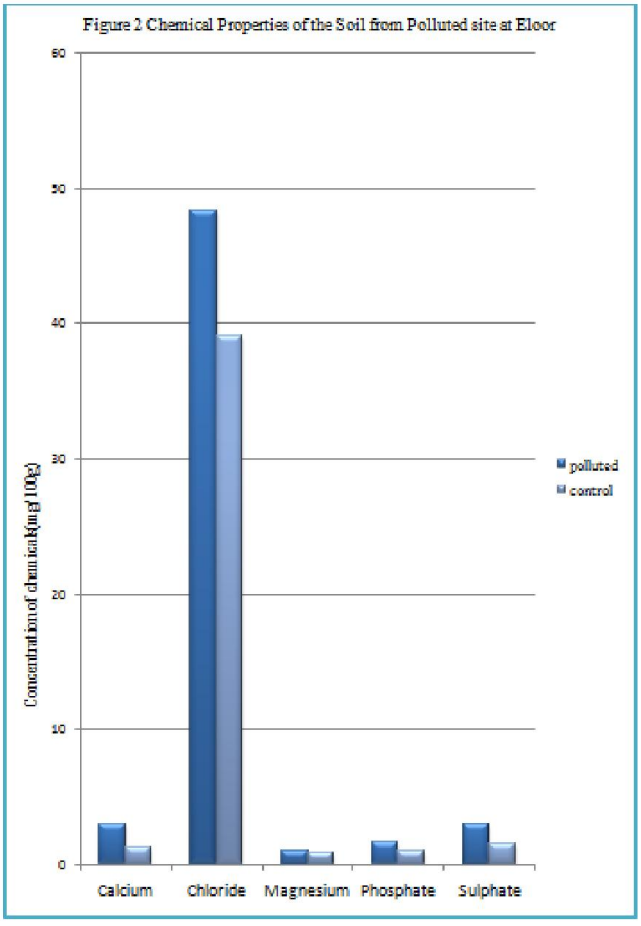
Table 2. Properties of Terrestrial soil from the polluted site of *Eloor*

Sl. No.	Tests	Polluted Site (Mg/100g)	Control Site (Mg/100g)
1.	P^H	8.49	7
2.	Alkalinity	1.2	0.5
3.	Organic matter	0.11	0.69

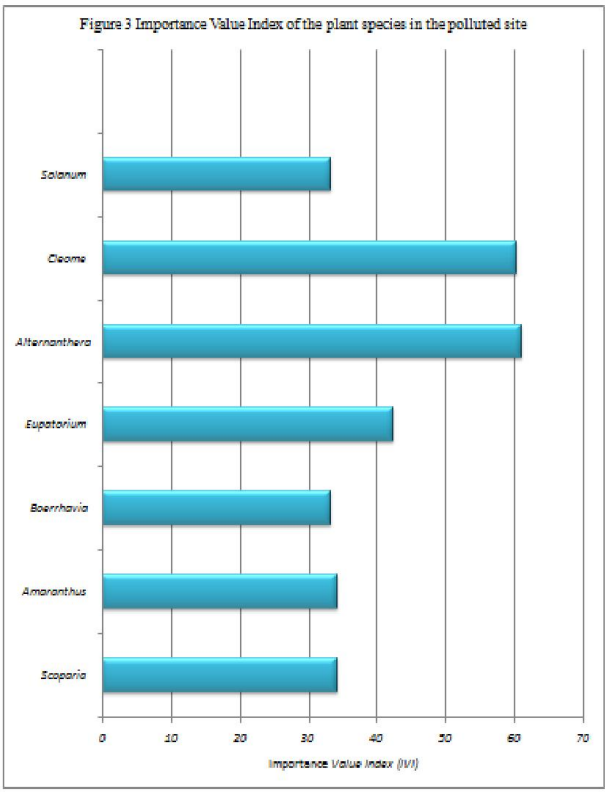
The wet polluted sample showed 2.9 mg and dry sample showed 2.6 mg calcium deposition. The control wet and dry samples indicated 1.9 mg and 1.3 mg calcium presence respectively (Figs. 1 and 2). The Chloride concentration of the wet and dry sample of the pollution prone sites were 49.7 mg and 48.28 mg and that of control sites were 36.92 mg and 39.05 mg respectively (Figs. 1 and 2).

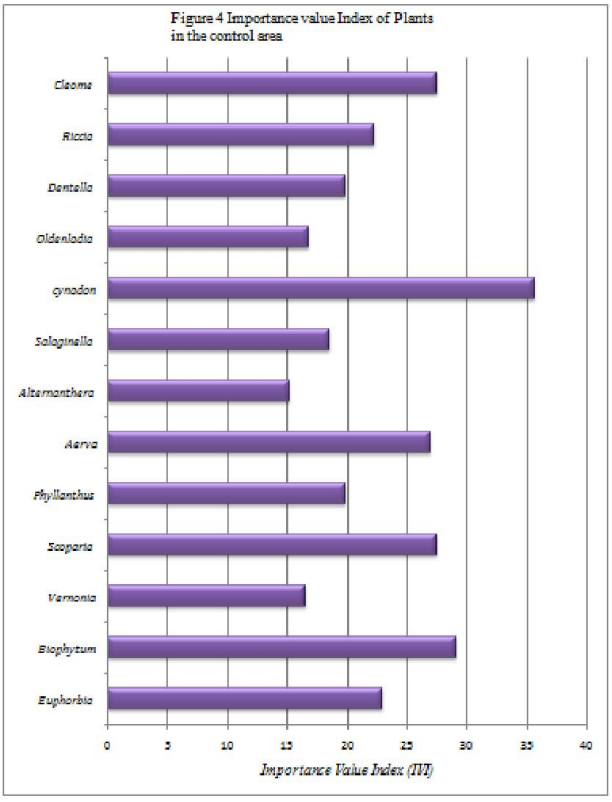
Again a lower amount of magnesium deposition seen in control samples i.e., 0.665 mg in wet and 0.901 mg in dry sample and the concentration in polluted samples were 1.127 mg in wet and 1.01 in dry samples respectively (Figs. 1and 2). Phosphate analysis of the soil revealed that the polluted wet and dry samples carried about 1.51 mg and 1.58 mg chemical occurrence whereas the control wet and dry ones supported 0.55 mg and 1.01 mg elemental presence respectively (Figs. 1 and 2)



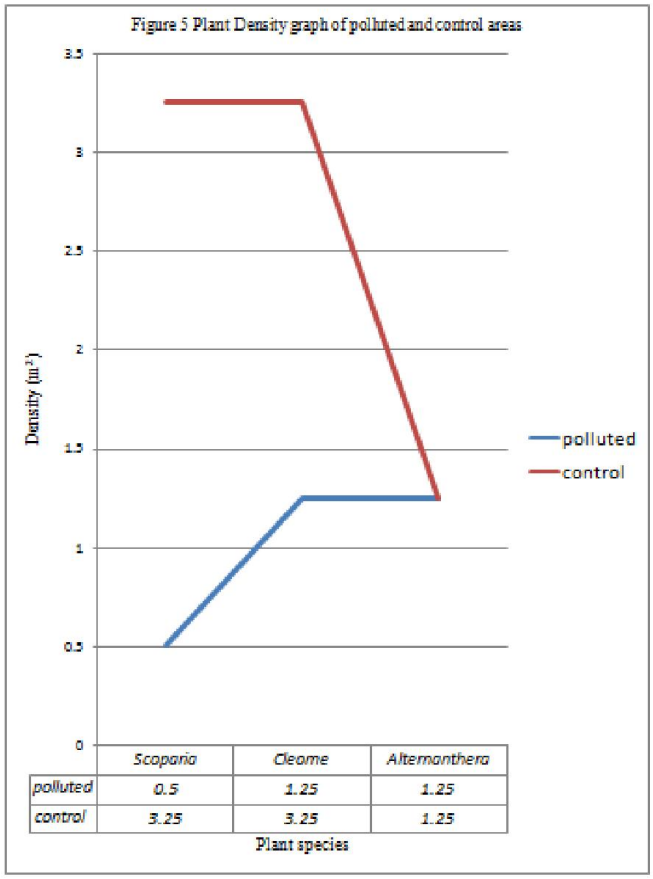


Sulphate examination exposed the presence of a higher amount of sulphate occurrence in the polluted soil and i.e., almost 2.85 mg in polluted wet and 3.02 mg in polluted dry samples. The control wet and dry had 1.5 mg and 1.55 mg sulphate presences (Figs. 1 and 2). The polluted site confirmed a higher rate of alkalinity.





It was almost 1.2 mg in dry sample and 1.5 mg in wet sample. The control sites established the presence of 0.5 mg in dry and 0.7 mg in wet sample respectively (Figs. 1 and 2).



The organic matter was high in non-polluted sample, that was nearly 0.568 % in wet and 0.698 % in dry sample and in case of control sample it was approximately 0.131 % in wet and 0.116 % in dry sample respectively (Figs. 1 and 2). The third analysis was the plant community study; it was a quantitative analysis in which quadrat method was adopted to obtain the data. It was done both in control and pollution zones. The investigation revealed that a greater diversity of plants was observed in control site and the diversity was so poor in the pollution prone area. Eloor zone consisted of only certain restricted varieties of plants. the parameters like density, frequency, abundance, IVI etc. were lower as compared to the control sites (Figs. 3, 4 and 5)

DISCUSSION

The present study aimed at analyzing the consequences of industrial pollution on the soil system. The endless dumping of the industrial wastes directly into the soil results in the buildup of chemical constituents in an alarming rate, which will badly interfere with the normal micro flora of soil ecosystem. All these alterations will progressively affect the normal plant biodiversity.

The examination involved the analysis of chemical features of the soil and the phytosociological aspects of Eloor. The zone selected for the same was Pathalam Bund, a heavily polluted area of Eloor. The control samples were taken from Desom, a nearby village. These two regions represented two ends of river Periyar. The former area is occupied with several industries and is heavily polluted whereas the other is a serine village free of toxic waste.

Both aquatic and terrestrial soil samples were analyzed from the above two sites. The term pH is the direct measurement of the balance between acidic hydrogen ions (H+) and basic hydroxide ions (OH-). The pH of a solution can range between 0 (acidic) and 14 (basic). At pH of 7.0, the concentrations of H+ and OH- are equal, and the solution is said to be neutral. When the pH is above 7.0, the concentration of OH- is higher than H+, and the solution is said to be basic or alkaline (not alkalinity). When the solution is below 7.0, the concentration of H+ is higher than OH-, and the solution is said to be acidic (Argo 2003).

pH of the polluted samples showed alkalinity and it was 8.49 for polluted dry and 8.1 for polluted wet samples. The control samples of both aquatic and terrestrial origin showed a neutral pH. The higher pH of the soil may be due to the accumulation of industrial waste having alkaline nature. Ammonia is one of the major chemicals produced by the industrial units in the area. pH variation from neutrality will have trouble in nutrient solubility in soil. pH above 7.5 makes the soil unsuitable for iron, zinc, copper, manganese solubility. As a result plants show visible symptoms of stress and injury. The plants growing in this soil showed decreased rate of photosynthesis, stunted vegetative growth, die back symptoms *etc.* Another important aspect is that alkaline pH makes the soil environment suitable for the flourishing of pathogenic bacteria like *Staphylococcus* sps*, Clostridium tetani, Corynebacterium diptheriae etc.* and suppresses the growth of normal soil bacteria (Jarvis. 2004).

The analysis of calcium in the soil showed a higher rate of deposition in the polluted sites. The dry polluted site showed 2.9 mg and the wet polluted site had 2.6 mg calcium presence whereas the control sites had its level below 2 mg. Calcium is a macronutrient essential for the proper plant growth. It is an important component of the plant cell wall in the form of calcium pectate, cell membrane and also has vital roles in cell signaling mechanisms in all organisms. But a higher amount of Calcium in the soil is detrimental to the growth of soil microorganisms and also will support only calcicole plants. This will definitely result in a drastic decrease in plant biodiversity. The hardness of the water is mainly caused by excess calcium in the water which provides a scum appearance to the water which may interferes with the usual sunlight penetration followed by hindrance of normal metabolism of aquatic flora. So the soil leach out containing higher levels of calcium occurrence indirectly increases the hardness of the water and alters the aquatic productivity. Upsurge in the water hardness surely increases the pH also which will affect the normal bacterial and plant communities of the area (Yanamadala, 2005).

Chlorine was yet another important chemical found in the soil, its presence was also very high in the polluted samples. It was 49.7 mg and 48.28 mg in aquatic and terrestrial soil samples respectively whereas it was below 40 mg in the control samples. Chlorine is one of the major chemicals produced by

the neighbouring industries in the form of DDT, Chlordane *etc*. Chlorine is an important micro nutrient needed by the plants for photosynthesis, cell division, keeping the osmotic balance etc. But when the chlorine level is above the optimum it inhibits proper seed germination and plant growth.

It also results in the development of necrotic lesions in leaves, stunted plant growth, chlorosis and disruption of photosynthesis. Occurrence of chlorinated waste in the soil makes the decomposition procedures much slower, this is because the decomposers cannot act on these wastes properly which is one of the reasons why chlorinated components have high persistence level. Also high chorine levels results in membrane damage and microbial inactivation of many bacterial colonies like *Bacillus* sps, Enterobacteriaceae members etc. (Virto 2009).

Magnesium was another chemical found in the polluted soil in higher concentration. It was observed to be 1.12 mg and 1.01 mg in aquatic and terrestrial polluted samples and 0.66 mg and 0.9 mg in aquatic and terrestrial control samples respectively. Along with calcium, soil leachate containing magnesium also increases water hardness and pH (Yanamadala 2005). The water hardness will definitely destroy the aquatic photosynthesis by making a scum appearance in the water and also the pH increase will alter the normal plant and bacterial flora of the affected area. In the polluted sites phosphate was detected to be 1.51 mg and 1.58 mg in aquatic and terrestrial samples however it was only 0.55 mg and 1.01 mg in aquatic and terrestrial control samples correspondingly. Phosphate is an essential component of most of the fertilizers, which are produced by most of the nearby industries.

Increase in the phosphate level mainly disturbs the aquatic environment by an unusual enrichment of water which will results in eutrophication process (Ansar 2005). It is an alarming growth of algae and bacteria of aquatic environment. It results in the formation of a slimy layer over the water surface which will inhibit the light penetration into the water and also lessen the dissolved oxygen level. So that the organisms present in the lower levels of water may die because of lack of light and dissolved oxygen. It may again worsen the condition by creating an intense anaerobic condition which causes foul smelling and turbid appearance in water. It may slowly enhance the growth of disease causing bacteria (Yanamadala 2005). This may ultimately result in the gradual death of lakes and rivers like that of river Periyar. This may be one of the reasons for the mass death of fishes in this river. Thus phosphate pollution greatly modifies the typical plant and microbial flora of a polluted site.

Sulphate level was again high in polluted soil samples. The adjacent industries are producing sulphur in the form of SO_2, H_2SO_4 and as an important constituent of fertilizers, insecticides etc. The sulphate composition was found to be 2.85 mg and 3.02 mg in aquatic and terrestrial pollution sites and it was 1.5 mg and 1.55 mg in control aquatic and terrestrial samples respectively. Sulphate contamination primarily affects the usual bacterial community in the soil. It badly causes problem to its normal metabolism (Duarte 2007). Excess amount of sulphate in the soil stimulates the plants to take more amounts of heavy metals like arsenic, which are venomous (Memon 2004). Alkalinity or acid buffering capacity is the concentration of acid needs to lower the pH below a certain level. It differs from pH where only the H^+ ion concentration is taken into consideration. Alkalinity is not due a single ion but by the effect of several ions like calcium, magnesium, phosphates, silicates, sulphides etc. (Argo 2003).

A rise in any of the above components beyond a limit enhance alkalinity. The relationship between alkalinity and pH is that a rise in the former surely rises the latter. The alkalinity was found to be high in polluted samples and it was 1.5 % and 1.2% in aquatic and terrestrial samples and 0.7 % and 0.2% in control aquatic and terrestrial samples respectively. Since alkalinity of soil is a net effect of several ions, a rise in this parameter definitely alters the plant and microbial cover of the site.

Plant organic matter is an important component of the soil consisting of plant and animal residues at various stages of decomposition. It plays an important role in the physical and chemical properties of soil. It is also an important parameter which reflects the quality of soil. The plant organic matter was found to be high in control sample, it may be due to high organismic cover in the unpolluted site, and it was 0.13 % and 0.11 % in polluted aquatic and terrestrial site and 0.56 % and 0.69 % in control aquatic and terrestrial sites respectively. The soil organic matter stabilizes soil structure, improves water retention, and provides proper drainage and aeration. It will also retain the nutrients of soil and also resist the change in pH. Hence the soil organic matter has got a direct impact on the soil fertility. So the decline in the soil organic matter greatly shakes the organismic population of an area especially the microbes and plant forms which were the prime victims of this problem.

The Phytosociological results revealed that the plant diversity was too less in the polluted site. Only seven plant species occurred in the quadrat study when it was carried out in polluted site however same study showed 13 different plant species in the control region. In the polluted site almost all the densities were below 1.5 and the average density was 0.75 while control site showed that majority of the plant species had a density above 2.5 and the average density was 2.07. Plants which were common in both polluted and control sites were *Alternanthera sessilis* R.Br, *Cleome viscosa* L. and *Scoparia dulcis* L. but their density, abundance, frequency,IVI are found to be very high in control site. These plants have got high tolerance capacity. Importance value index greatly helped in analyzing the dominant species of a community. It is an important ecological tool (Sharma 2009). In the polluted site *Alternanthera sessilis* R.Br and *Cleome viscosa* L. were found to be the dominant ones while in the control site *Cynodon dactylon* L. was the dominant species.

The most abundant plant species in the control zone was *Cynodon dactylon* L. and its abundance was 4.75 while the abundant plant species of the polluted site was *Cleome* and its abundance was 2.5. Grass members were totally absent in polluted site. *Cleome viscosa* L. the most abundant plant species of polluted site was found in the control site with a greater abundance level, 3.25. A relationship existed between

the changes in the soil factors due to pollution and the plant responses. In a polluted site initially the trees will vanish followed by shrubs and lastly the herbs (Pandey, 1982). *Eloor* site also supported this fact, that major plant groups in this area were herbs followed by shrubs whereas the number of trees was so limited. The polluted site was represented with certain restricted groups of plant species *viz.* *Scoparia dulcis* L., *Ficus religiosa* L., *Boerhaavia diffusa* L., *Amaranthus spinosus* L., *Psidium guajava* D.C, *Calotropis procera* L., *Alternanthera sessilis* R.Br, *Eupatorium birmanicum* L., *Solanum torvum* Swartz Many of these plants have high pollution tolerance level and are pollution indicators. *Boerhaavia diffusa* L. and *Amaranthus spinosus* L. can alter their physiological pathways according to the pollution level, they can also manage their stomatal movement. Also during stress condition plants like *Boerhaavia diffusa* L.can shift over from C_3 to C_4 pathway (Mandal, 2006). *Scoparia dulcis* L. have high resistance against industrial chemicals (Gaundi, 2005). Plants like *Psidium guajava,* D.C, *Ficus religiosa* L., *Calotropis procera* L. have high dust trapping capacity (Barik *et al*., 2005). *Solanum torvum*, Swartz is known for its high rate of seed germination in polluted habitat (Arora *et al*., 2006). The occurrence of these indicator plants is clear evidence indicating high levels of soil pollution in the area.

Conclusion

The ruthless dumping of the industrial waste into the surroundings resulted in a chain of problems. The present study is also a supporting fact for that. The toxic manufacturing waste first hampered the chemical and biological aspects of the soil followed by creating problems to the plants then to animals and moved to the rest portion of food web. Mass death of fishes in the Periyar river near Pathalam zone is a recurrent phenomenon. The international studies had reported that the inhabitants of this area were suffering from many rare fatal ailments. These miseries can be read together and root cause of all may be the very same industrial bang. It needs strong further studies. The present work is a small supporting proof for the anthropogenic act that destroys the purity of a serine land, Eloor. The main goal of the analysis is to create an awareness among the people about the burden of industrialization. The results can be later communicated to the authorities or policy makers. So that they can make effective policies and implement them which may solve the problem else the Eloor zone slowly becomes a poisoned graveyard. So the investigation revealed that polluted site showed a great variation in the soil chemistry, microbiology and the phytosociology. When the parameters were compared with the control samples the pollution extent was observed to be very high.

Acknowledgements

The financial assistance from UGC is gratefully acknowledged. The authors are indebted to the Head, Department of Botany, St. Teresa's College (Autonomous), Ernakulam and the Principal, St. Teresa's College (Autonomous), Ernakulam for their support and encouragement.

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