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Assessment of a Hydrocarbon Exploration Site in North Eastern State of Tripura

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ABSTRACT

Recently abandoned hydrocarbon exploration sites generally support a smaller number of plants since there are few spaces for plants to grow and survive in the exploration site with all the concrete structure around and very few areas of soil to support vegetation. Metals are required by plants for their growth while a higher level can cause the plants to die. The study has been conducted to explore the concentration of metals in an abandoned hydrocarbon exploration site and their adjacent site of Tripura to determine the species diversity in the area with the metal concentration. The highest concentration of iron, chromium, and sulfur in the site were recorded in *Chromolaena odorata*, *Urena lobata* and *Crotalaria pallida*. All the plants collected have some levels of iron, chromium, and sulfur in their shoot as well as their roots. This study will be beneficial as the plants which have highest level of a particular metal can be used in future research to remediate the area of that metal. In this way, the cost of searching for plants to be used for phytoremediation experiment will also be reduced. The growth of plants in the abandoned hydrocarbon exploration sites will also help in reducing the contaminants of that sites.

Keywords Abandoned, Metals, Species diversity, Phytoremediation, Contaminants.

INTRODUCTION

Natural as well as anthropogenic activities has led to contamination of the environment both soil and water. Hydrocarbon exploration sites are generally of great concern due to numerous activities undertaken at the sites. Since hydrocarbon contaminants have long term adverse effects on human health as well as soil ecosystems, it has become a global concern (Ruley *et al.* 2019). There is need to develop a new technology to remove the contaminants from the environment as land is a non-renewable resource. Due to uncontrollable population rise universally, more land is needed to accommodate the increasing population. Excavation is the most prevalent, well-established technique for remediating contaminated soils, followed by landfilling or inceneration (Adipah 2019). Additional technologies that have been widely used include centrifugation, solvent extraction, photocatalysis, solidification/stabilization, ultrasonic treatment, land farming, pyrolysis, and

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biodegradation (Aeslina and Ali 2017).Therefore, the search for an alternative energy which could remediate the place without much harm is of extreme importance. Recently, the term "Phytoremediation" is becoming popular for the cleanup of contaminated sites. It is the use of plants in order to remediate a contaminated site. When microbes are used to remediate a place, it is known as bioremediation. Plants have been used for a variety of purpose by humans since time immemorial. It provides us food, fodder, shelter, medicines. Countries like India, Pakistan, China, Bangladesh, Taiwan, Thailand, Sri Lanka, Japan, Bhutan, Malaysia, and many African countries uses medicines based on plants as primary healthcare (Prashith Kekuda *et al.* 2019).

With rapid industrialization and urbanization,numerous places have been designated as contaminated sites and this trend will continue in the years to come. There are many sources of contaminants coming from untreated industrial outlets or sewage systems. Many plants have already been identified as potential remediator of a particular contaminants or different types of contaminants from a site. Since plants are found to be growing naturally in the environment with little to no maintenance, the procedure is relatively simple (Devi and Dasgupta 2022). There are various advantages of this process when compared with the conventional physical and chemical treatment. Some of the advantages are low cost, low maintenance, aesthetically pleasing and most importantly environment friendly. The main objective of this study was to conduct reconnaissance survey in anabandoned hydrocarbon exploration site and their adjacent sites to find out the vegetation composition of the area along with the iron, chromium, and sulfur content in the soil and plants collected to determine which plant species absorb or store the highest concentration of the metals in the root and shoot part of the plant. The result so obtained would be beneficial to those working in the field related to restoration of sites.

Due to massive industry and population growth, followed by uncontrollable weather conditions, this substantial increase in chemical impurity in soil is especially pronounced in emerging countries like India (Arora *et al.* 2017).

MATERIALS AND METHODS

The study site was an abandoned hydrocarbon exploration site of Tripura. Soil and plants samples were collected from the site and their adjacent site. It was designated as ONGC Bikramnagar site, 23.7529°N, 91.2688°E and Bikramnagar Adjacent site (23.7279^{0}N, 91.3093^0 E. The soil was prepared for analysis by air drying, powdering and then sieving. Plants found in the sites were identified, separated into roots and shoots, oven dried, powdered, and then sieved. The biomass of the collected plants was calculated after oven drying. The important value Index (IVI) for different species was calculated as sum of relative frequency (RF), relative density (RD) and relative abundance (RA) of each species (Singh *et al.* 2011). The correlation was calculated using SPSS software, Version 20. Iron, chromium, and sulfur content were then determined using UV-Vis Spectrophometer (Model No-1900I).

The translocation factor, the ratio of shoot to root metals, indicates internal metal transportation (Mazumdar and Das 2015). Translocation factor was calculated following the formula given by Deng *et al.* (2004).

$$TF = Metal_{shoot} / Metal_{root}$$

The ability of plants to take up heavy metals from soil was calculated by Bioconcentration Factor (BCF). The Bioconcentration factor was calculated as done by Zayed *et al.* (1998).

$$BCF = \frac{\text{Trace element concentration in plant tissue } \left(\frac{mg}{kg} \text{ at harvest}\right)}{\text{Initial concentration of the element in the external nutrient solution } \left(\frac{mg}{L}\right)}$$

RESULTS

Correlation was determined using SPSS and it was found that there was no significant link between Biomass and IVI at the ONGC Bikramnagar site Herb because the p-value (0.131) is more than the 0.05 level of significance ($p>0.05$) (Fig. 1).

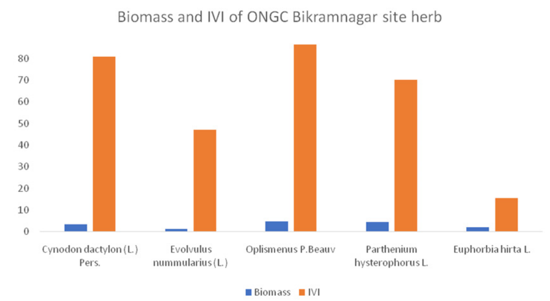

Fig. 1. Graph between biomass and IVI of ONGC Bikramnagar site herb.

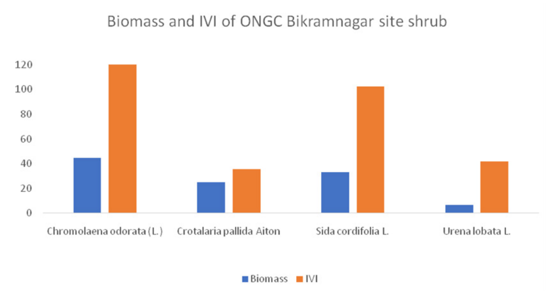

Fig. 2. Graph between biomass and IVI of ONGC Bikramnagar site shrub.

The correlation analysis between biomass and IVI of ONGC Bikramnagar site Shrub shows that there was no significant correlation between Biomass and IVI as the p- value (0.161) is more than 0.05 level of significance (p>0.05) (Fig. 2).

Correlation was determined between Biomass and IVI of Bikramnagar Adjacent Herb was calculated and no significant correlation was found between Biomass and IVI as the p- value (0.986) is more than 0.05 level of significance (p>0.05) (Fig. 3).

Correlation between Biomass and IVI of ONGC Bikramnagar Adjacent Shrub was calculated and there was significant correlation between them as the p- value is less than 0.01 level of significance (p<0.01) (Fig. 4).

The highest concentration of both iron and sulfur were recorded in ONGC Bikramnagar site followed by Bikramnagar Adjacent site. Chromium content was also highest in Bikramnagar Adjacent site followed by ONGC Bikramnagar site (Table 1).

The highest iron concentration was observed in root and shoot of *C.odorata*, chromium in *U. lobata* and sulfur in *C. pallida*. Most of the plants have TF factor greater than 1 while none of the plants have BCF_{root} greater than 1 (Table 2).

M. malabathricum has the highest iron content in both root and shoot parts. It also has highest sulfur content in shoot part. Chromium concentration was highest in *C. viscosumin* both root and shoot. It also has highest sulfur content in root part. *H. indicus* has high chromium and sulfur content when both root and shoot part was analyzed. Some of the plants have TF greater than 1 while none of the plant have BCF_{root} greater than 1 (Table 3).

DISCUSSION

From the experiment, it was observed that all the plants species found in all the studied site have some levels of iron, chromium and sulfur in their root and shoot part. The fact that plants were found growing in the sites were useful indication that plants can survive in the site. There are numerous studies by different researchers which proved that plants can be successfully used to clean up a contaminated site. Almost all

Table 1. Iron, Chromium and Sulphur content in soil sample collected from the sites. Data represents Mean±SEM for three replicates.

Site	pH	Moisture content (%)	SOC (%)	Iron (mgkg^{-1})	Chromium (mg kg^{-1})	Sulfur (mg kg^{-1})
ONGC Bikramnagar site	6.6	8.36	0.8	4.44±0.00	38.09±0.29	872.54±9.30
Bikramnagar Adjacent site	6.8	20.58	1.57	3.23±0.01	41.56±0.16	615.56±3.42

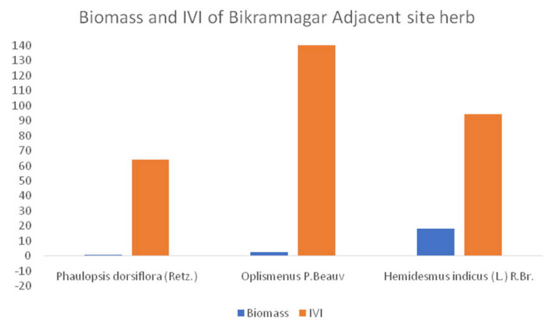

Fig. 3. Graph between biomass and IVI of Bikramnagar adjacent site herb.

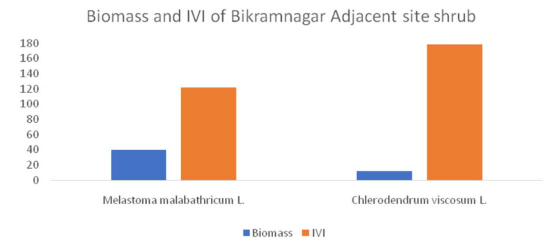

Fig. 4. Graph between biomass and IVI of Bikramnagar adjacent site shrub.

the plants found in all the studied sites were found to be previously used in phytoremediation experiment. A study conducted by Omoregie *et al.* (2019) showed that a significant amount of heavy metal in both ionic and non-ionic forms was accumulated by *C. odorata* in different plant parts and confirm that the plant has heavy metal sequestration capacity. *C. odorata* has been proved to have Cd uptake capacity showing rapid growth in both hydroponic and pot experiments with substantial biomass, and good performance Jampasri *et al.* (2021). Oseni *et al.* (2018) also concluded their study by reporting that *Sida acuta* and *C. odorata* shows the characteristics as a phytostabilizer as their TFs were less than one and absorbed a significant amount of lead and stored it in their roots.

IVI is the most important parameter for understanding community organization interms of competitiveness Uniyal *et al.* (2010). *C. odorata* has the highest IVI value while *C. pallida* has the lowest in the ONGC Bikramnagar site. In Bikramnagar Adjacent site, *C. viscosumhas* the highest IVI value while *C. minima* has the lowest. The high IVI value indicates that the subject species is the most dominant one in the area.

The highest concentration of iron was observed

Table 2. Iron, chromium and sulfur content in plant samples collected from ONGC Bikramnagar site. Data represents Mean±SEM for three replicates.

Plant name	Plant tissue	Iron (mg/kg^{-1})	TF	BCF root	Chromium (mg/kg^{-1})	TF	BCF root	Sulfur (mg/kg^{-1})	TF	BCF root
Cynodondactylon (L.) pers.	Root	0.01±0.00	1	0.002	4.46±0.85	1.25	0.12	157.56±1.19	1.05	0.18
	Shoot	0.01±0.02			5.08±0.51			165.78±0.87		
Evolvulusnummularius (L.)	Root	0.10±0.02	1.7	0.23	6.47±0.78	1.29	0.17	212.41±0.57	1.75	0.34
	Shoot	0.17±0.07			8.35±0.64			372.00±0.33		
Oplismenus P. Beauv	Root +Shoot	1.27±0.03			5.57±0.20			158.21±1.14		
Parthenium hysterophorus L.	Root	2.17±0.05	0.24	0.49	1.92±0.22	2.24	0.05	85.86±0.66	4.28	0.10
	Shoot	0.53±0.04			4.30±0.93			367.73±0.66		
Euphorbiahirta L.	Root	0.13±0.11	3.4	0.03	3.31±0.66	2.41	0.09	174.99±1.14	1.39	0.20
	Shoot	0.44±0.02			7.98±0.53			243.40±0.87		
Chromolaena odorata (L.)	Root	2.78±0.07	0.21	0.63	7.29±0.58	0.81	0.19	151.64±0.33	2.27	0.17
	Shoot	0.57±0.04			5.89±1.33			344.05±2.37		
Crotalaria pallida Aiton	Root	0.62±0.04	0.27	0.14	2.66±0.18	1.51	0.07	222.68±0.33	2.16	0.26
	Shoot	0.17±0.03			4.01±0.30			480.54±0.33		
Sida cordifolia L.	Root	1.00±0.01	0.4	0.23	4.22±0.68	1.29	0.11	116.77±1.14	2.59	0.13
	Shoot	0.40±0.03			5.44±0.68			302.93±0.33		
Urena lobata L.	Root	0.41±0.02	1.37	0.09	20.18±0.26	0.43	0.53	174.00±0.57	1.0	0.20
	Shoot	0.56±0.06			8.68±0.90			175.32±0.33		

Table 3. Iron, Chromium and Sulfur content in plant sample collected from Bikramnagar Adjacent site. Data represents Mean±SEM for three replicates.

Plant name	Plant tissue	Iron ($mgkg^{-1}$)	TF	BCF root	Chromium (mg/kg^{-1})	TF	BCF root	Sulfur (mg/kg^{-1})	TF	BCF root
Phaulopsisdor-siflora (Retz.)	Root+ Shoot	0.58±0.03			3.76±0.83			110.85±0.57		
Hemidesmus indicus (L.) R.Br.	Root+ Shoot	0.24±0.02			8.64±0.75			366.08±0.87		
Oplismenus P. Beauv	Root +Shoot	0.52±0.05			2.95±0.78			157.89±0.33		
Melastomam-alabathricum L.	Root	1.45±0.06	1.38	0.45	6.51±0.78	0.83	0.15	95.39±0.87	4.80	0.15
	Shoot	2.00±0.06			5.40±1.01			457.52±0.33		
Chlerodendrum-viscosum L.	Root	0.06±0.03	0.73	0.18	6.71±0.46	2.23	0.16	200.31±0.87	2.25	0.33
	Shoot	0.48±0.03			14.94±0.94			450.28±0.57		
Hevea brasilie-nsis Mull. Arg.	Leaves	0.00±0.01			8.35±1.14			166.77±2.00		
	Stem	0.01±0.00			15.68±0.43			303.92±0.87		

in *C. odorata* followed by *P. hysterophorus* while the lowest concentration was found in *C. dactylonin* ONGC Bikramnagar site which has almost no iron concentration in the shoot and root part. The concentration of iron in rubber plants was also found to be very low. Plants which have TF values more than 1 signifies that they store metals in the shoot parts more than their root parts (Devi and Dasgupta 2021). The highest TF value (3.4) of iron was found in E. hirtain ONGC Bikramnagar site. *M. malabathricum* was also reported to be an extremely active phytoextractor of Mn, Pb, Cu, Fe and Zn (Patek-Mohd et al. 2018). Its TF value was greater than 1 in this study. Around 4 plants in the different sites have TF value greater than 1. All the plants found in both ONGC Bikramnagar site and its adjacent site have BCF value less than 1. This means that plants found in the site have low ability to take up metals from the site. For phytoremediation experiment, plants which have BCF value (preferably >1) are regarded as suitable Deepa *et al.* (2015).

U. lobata in ONGC Bikramnagar sitehas the highest chromium concentration followed by *C.viscosum* of Bikramnagar Adjacent site. The lowest concentration was found in *P. hysterophorus*. Rubber plants also have some levels of chromium in both the root and shoot part. The highest TF value (2.41) of chromium was observed in *E. hirtain* ONGC Bikramnagar site. Out of 9 plants found in ONGC Bikramnagar site, 7 plants have TF value greater than 1 whereas none of them have BCF value greater than 1. In case of Bikramnagar Adjacent site, only one plant has TF greater than 1 while all the remaining have both TF and BCF less than 1. Plants having TF values greater than 1 means that they are efficient in transferring the absorbed metals from the root to the shoot part while low BCF is an indication that the metals are not easily absorbed by the plants.

Sulfur content was highest in *C. pallida* of ONGC Bikramnagarsite. The concentration of sulphur in rubber plant was also high. The lowest sulphur content was found in *P. hysterophorus* of ONGC Bikramnagar site. The highest TF value (4.80) of was observed in *M. malabathricum* of Bikramnagar Adjacentsite. All the plants of both ONGC Bikramnagar site and Bikramnagar Adjacent site have TF greater than 1 and BCF less than 1. This may be because soil sulphur content was very high in the site but it might not be in the form in which plants can easily absorb the metal from the soil.

CONCLUSION

The study demonstrated that almost all the plant species found in the sites have some level of metals (iron, chromium and sulfur) in their shoot and root parts. The study is significant as there is no previous study conducted regarding the metal concentration in plants. This will serve as a baseline data for future study. The highest concentration of iron, chromium, and sulphur were recorded in *C. odorata*, *U. lobata* and *C. pallida*. It is also evident that many plants found in different sites have TF values greater than 1 which means that a lot of plants store the translocated metals more in the shoot part than in the root part. The BCF values greater than 1 also indicates that plants can absorb metals from the soil and stored it in the root part. The study has shown all the plants which can be used in phytoremediation experiment in the future. Study regarding phytoremediation is in a very infant stage and future research can also focused on using genetic engineering technique to increase the phytoremediation potential of the plants. It is also reported in some studies that the experiment can be enhanced by using amendments like organic fertilizers or NPK or any other substrates. Study can also be done on disposal of the plants which are used in the experiment. There are very few studies regarding its disposal. Hence, detailed experiments in the future are needed to come to a clear conclusion.

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