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Phytoremediation as a Sustainable Approach for Heavy Metal Cleanup in Mining Affected Soils of Baikunthpur Chhattisgarh

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Abstract: Chhattisgarh is rich in mineral resource. At many places the work on the metal analysis has been performed but Baikunthpur area which is thickly surrounded by coalmines, soil of these areas are affected by the coal mining activities, so that their monitoring is very much required. Phytoremediation is a natural method which has yet not been used in this estimated area. In this research work Phytoremediation method has been introduced to reduce or remove heavy metals in contaminated soil. With the study's goal in mind, the sampling sites are chosen so as to cover the regions surrounding the Baikunthpur district in Chhattisgarh, India, where there is a significant likelihood of contamination.

Keywords: mineral resources, coal mines, phytoremediation etc

I. INTRODUCTION

Coal mining is an essential resource for the advancement of society and has a big economic influence. It is widely but unevenly distributed throughout the Indian state of Chhattisgarh, and it is concentrated in areas with sensitive ecological habitats in the north of the state [1]. The destruction of the environment caused by coal mining and the reconstruction of mining areas are major concerns for researchers. Many heavy metals found in the accumulated debris from coal mining would eventually poison the surrounding soil and water sources, killing the local vegetation [2]. Heavy metals the name has so many ways, based on various factors such as density and atomic weight [3]. There is no consensus on definition of a heavy metal. It is either a metal of high density or a toxic, relatively dense metal [4]. Some metals, such as lead and mercury, are both dense (heavy) and toxic. Lead and mercury are universally agreed to be heavy metals [5].

Because HMs are found in the environment and have important ecological ramifications due to their toxicity at particular concentrations, translocation across food chains, and non-biodegradability, which leads to their assembly in the biosphere. In order to meet human demands for a healthy environment and a supply of high-quality food, soil is a crucial natural resource, according to [6]. Through foliar absorption or mobile roots, plants grown on ground contaminated by domestic, industrial, or municipal pollutants can absorb heavy metals from the soil solution. The ingested metals are bioaccumulated by the plant's roots, stems, fruits, grains, and leaves. certain heavy metals are very dangerous to humans, animals, and plants, such as As, Cd, Hg, and Pb. Heavy metals play important roles in a variety of oxidation-reduction processes and are essential parts of some vital enzymes [7]. For example, several oxidative stress-related enzymes, including ferroxidases, catalase, superoxide dismutase, peroxidase, cytochrome c oxidases, monoamine oxidase, and dopamine β-monooxygenase, require copper as a co-factor. As a result, it is an essential ingredient that is incorporated into a number of metalloenzymes that are involved in the production of hemoglobin, the metabolism of carbohydrates, the production of catecholamines, and the cross-linking of keratin, collagen, and elastin in hair [8].Cuproenzymes that are involved in redox processes exploit copper's capacity to cycle between an oxidized state, Cu(II), and a reduced state, Cu(I). But because superoxide and hydroxyl radicals can be produced during the transitions between Cu(II) and Cu(I), this feature of copper also gives it the potential to be poisonous [9]. Additionally, high copper exposure has been connected to human Wilson disease-causing cellular damage. Like copper, a number of other elements are necessary for the proper operation of the body; nevertheless, an excess of these metals causes damage to cells and tissues, which can result in a host of negative effects and disorders in humans [10]. There is a relatively small range of concentrations for certain elements, such as copper and chromium, between advantageous and harmful effects. Other metals include bismuth (Bi), cadmium (Cd), gallium (Ga), germanium (Ge), gold (Au), indium, barium (Ba), antinomy (Sb), arsenic (As), and beryllium (Be).

1.1 Heavy metal toxicity

While some heavy metals are essential to human biology, over exposure to them can have unintended detrimental effects on the body's systems and general health. There are numerous mechanistic components to heavy metal-induced toxicity and carcinogenicity, some of which are not fully understood or clarified [11]. However, it is well acknowledged that each metal possesses unique properties and physicochemical attributes that result in specific toxicological. The molecular mechanisms of toxicity, genotoxicity, and carcinogenicity of arsenic, cadmium, chromium, lead, and mercury as well as their environmental occurrence, production and utilization, and potential for human exposure [12]. Although certain heavy metals are necessary for human biology, their amount can have unanticipated negative consequences on health and the body's systems. Studies shows that despite of its beneficiary health effects, heavy metals are acting as carcinogenic agents [13]. Dissolved forms of these metals through different forms as soil pollutants, water pollutant and air pollutants entering into food chain and finally ending in humans, these are leading to severe damage to the cellular system and leading to expose towards cancer. According to the reports of the International agency for research on cancer non-essential heavy metals (As, Cd, Cr) are major cancer-causing agents.

Phytoremediation

Using processes like bioaccumulation, phytoextraction, rhizofiltration, or phytostabilization, certain plant species' innate capacity to eliminate or stabilize metal-contaminated soils is commonly used in the remediation process [14]. Utilizing plants to remove pollutants from the environment is known as phytoremediation. Given the significant expenses associated with site remediation, it is critical that we keep creating and improving novel, low-cost techniques for environmental cleanup. When corrective action is still being taken, phytoremediation also has the advantage of aiding in site restoration [15]. Phytoremediation has also been called green remediation, botano- remediation, agro remediation and vegetative remediation. Itis a less destructive to the environment, cost effective, aesthetically environmental pollutants removal approach most suitable for developing countries. In order to shorten the treatment period, the plant utilized in the phytoremediation process needs to have a significant capacity for absorbing metals and to accumulate and strengthen those metals [16]. Plants may clean up or remediate contaminated environments in a variety of ways. Using energy from sunlight, plants have the innate ability to remove toxins from water, soil, and air. This process is known as phytoremediation. Among its benefits are it slower cost, passive and solar energy source, high level of public approval, ability to preserve top soil, and reduced production of secondary trash.

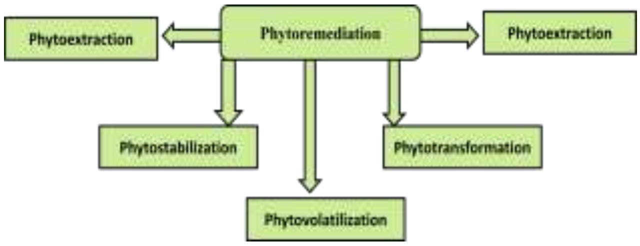

Figure- 1Techniques of Phytoremediation

II. METHODOLOGY

Phytoextraction also known as phytoaccumulation [17]. Contaminated soils are the main application for phytoextraction. It is the most effective method for isolating and removing heavy metal pollution, mostly from soil. Pollutants can be removed from the environment by employing the phytoextraction or phytoaccumulation approach, in which plants that have the capacity to gather pollutants and heavy metals (HMs) from the soil store them in their shoots for later harvest [18]. Through direct incorporation into plant biomass, this method eliminates radionuclides, metals, and certain organic molecules. Heavy metals can be extracted from polluted soil using one of two primary types of phytoextraction methods.

i) Induced phytoextraction, in which artificial chelates are added to increase mobility and uptake of metal contaminant.

ii) Continuous phytoextraction, in which removal of heavy metal depends on the natural ability of plants to remediate only the number of plant growth repetitions are controlled.

2.1 Study Area

With the study's goal in mind, the sampling sites are chosen so as to cover the regions surrounding the Baikunthpur district in Chhattisgarh, India, where there is a significant likelihood of contamination. The research area is located in Baikunthpur, Chhattisgarh, a coal mining district. Between 22°56′ and 23°48′ North and 81°56′ and 82°47′ East is where Koriya District is located. Given that the study area is Baikunthpur, Chhattisgarh's mining region. because there are numerous coal plants all around the Baikunthpur area. As a result of former coal mining activities.

The soil shows elevated contents for many heavy metals [19]. The following factors were considered for selection of the sample sites: (I) Locations where the presence of coal mining is thought to increase the likelihood of pollution. (II) Sites near the populated areas. (III) Sites where probability of contamination is higher due to mode and source of coal mining activities. (IV) Locations of agricultural activities.

1. The Churcha coal mine is operated by South Eastern Coalfields Limited, a subsidiary of Coal India, in the villages, Sardi and Shivpur, Tehsil Baikunthpur, District Korea, State Chhattisgarh, India. GPS coordinates, latitude 23.335952 and longitude – 82.519611.

2. The Katkona Underground Coal Mine has a designed capacity of 0.36 MTPA on a mining lease area of 1130.929 ha. In village Murma&Katkona, Tehsil Baikunthpur, District Korea, State Chhattisgarh, India. It is operated by South Eastern Coal field limited. GPS coordinates, latitude - 23.359829, longitude – 82.680745.

3. The Pandavpara Coal Mine has a designed capacity of 0.5 MTPA on a mining lease area of 972.036 ha. It is operated by South Eastern Coalfields Limited, the project received its environment clearance for an expansion in capacity from 0.201 MTPA to 0.50 MTPA on 4 May 2009. Village Sorga, Tehsil Baikunthpur, District Korea, State Chhattisgarh, India. GPS coordinate, latitude – 23.350314 and longitude – 82.728807.

4. The katgodi coal mine is another part of churcha coal mines. GPS coordinates,latitude – 23.33795, longitude – 82.4981

Indianmustard (Brassicajuncea) is used for phytoremediation, this plant can extracting, sequestering, or detoxifying heavy metals from contaminated soils [20]. Indian mustard is a hyper- accumulator herb that can absorb heavy metals from soil and water and store them in its shoots. It has been observed to be an efficient efficient phytoremediator of some heavy metals. This mustard plant is used in phytoremediation to remove heavy metals, such as lead, from the soil in hazardous waste sites because it has a higher tolerance for these substances and stores the heavy metalsin its cells [21]. In particular, Brassica juncea was particularly effective at removing cadmium from soil. The process of removing heavy metals ends when the plant is harvested and properly discarded. As International Journal of Molecular Sciences has published, heavy metals affect not only industrial sites but also cultivated land, spreading risks for human health. Brassicaceae species are really useful to accumulate certain metals while producing high quantities of biomass in the process, and Indian mustard is the star of this group [22].

Plant taxonomy: Kingdom: Plantae

Phylum: Magnoliophyta

Class: Magnoliopsida

Order: Capparales

Family: Brassicaceae

Genus: Brassica

Species: juncea

By using Phytoextraction method of Phytoremediation technique, initially the seeds were sown in clay pots of four soil samples and watered with tap water. After 10 inch growth of plants, the root of the sample species werecollected and taken to the laboratory for determining the presence of heavy metals [23].

2.3 Soil sample collection

As the study area is situated in mining area of Baikunthpur, Chhattisgarh, Because Baikunthpur area is surrounded by many coal plants. As a result of former coal mining activities. The soil shows elevated contents for many heavy metals. Soil sample were collected at 0-15 cm depth from three different sampling sites. Soil samples were collected and taken to the laboratory using sampling bags with proper distinction. Samples collected from nearest crop field of four different coal mining sites and coded as –

PS1 -CHURCHA **PS2–KATKONA**

PS3-PANDAVPARA **PS4-KATGODI**

Table1: Samples were coded as:

Area	Soil sample with plant
PS1	**PS1a**
PS2	**PS2a**
PS3	**PS3a**
PS4	**PS4a**

III. OBSERVATION AND ANALYSIS

The soil samples will digested using the Jou (1982) method. The roots and shoots sample will digested using the Audo and Lawal (2005) procedure. Heavy metal concentration in each of the samples will analyzed using Atomic Absorption Spectroscopy (AAS) syntronic.

Observation and analysis are key components of scientific inquiry and critical thinking. To collect data, find patterns and links, and test hypotheses in scientific research, observation and analysis are employed [25]. While analysis entails looking at and interpreting the data to draw conclusions and make inferences, observation requires utilizing the senses or tools to obtain information [26].

- **Heavy metal concentration**

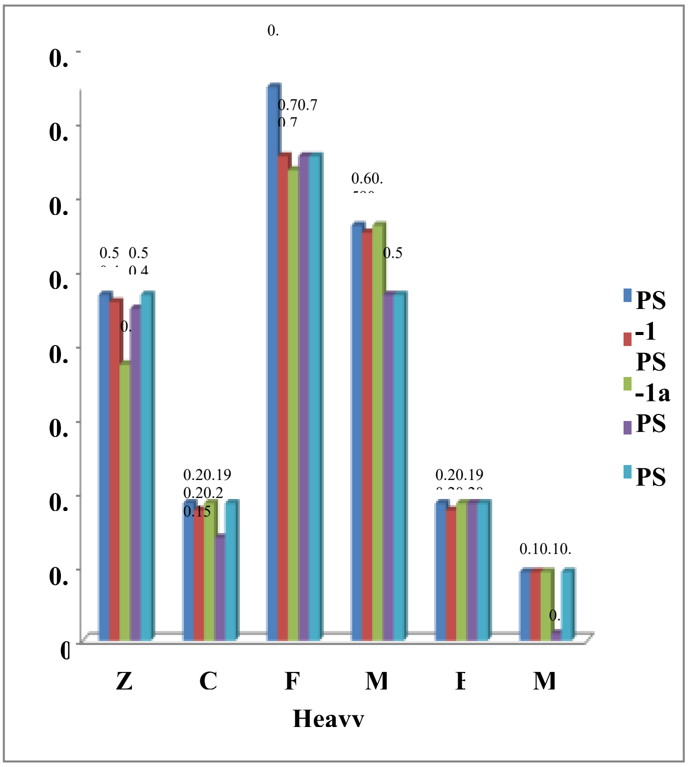

Fig. 2: Concentration of heavy metals in mg/kg of PS-1 soil samples

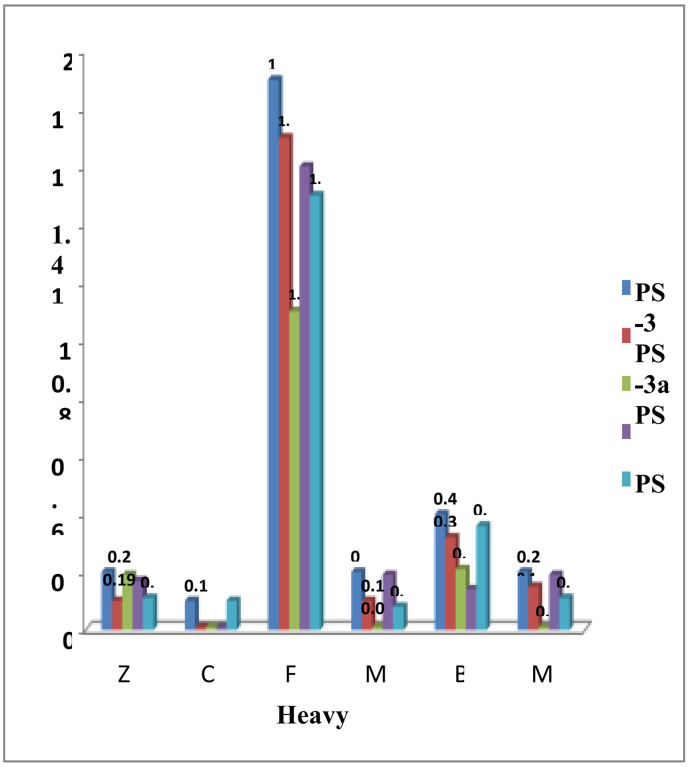

Fig. 4: Concentration (in mg/kg) of different heavy metals in PS-3 soil sample

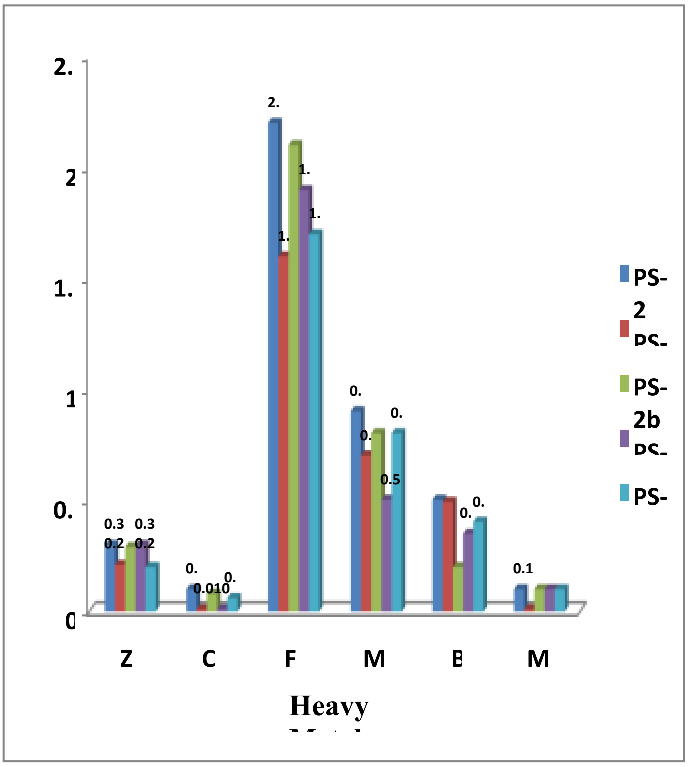

Fig. 3: Concentration of heavy metals in mg/kg of PS-2 soil sample

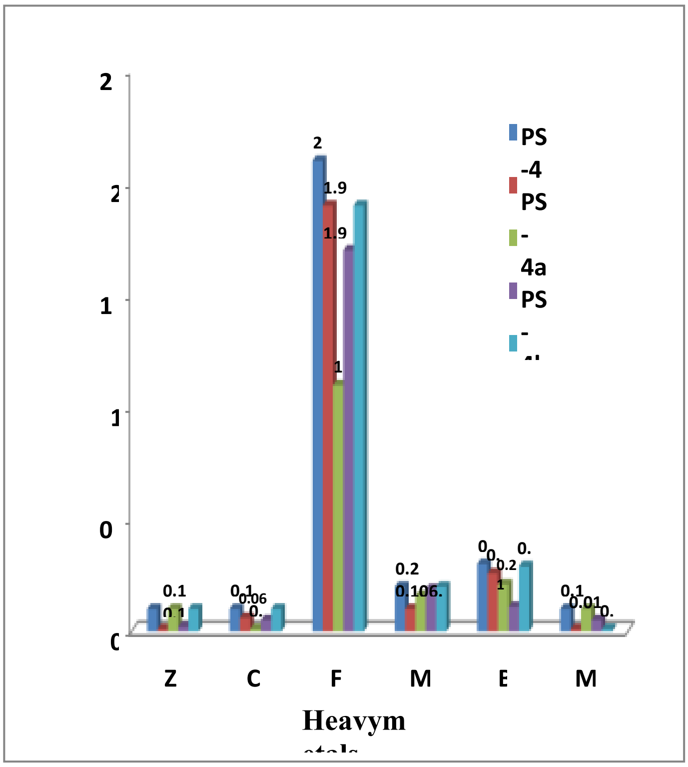

Fig. 5: Concentration (in mg/kg) of different heavy metals in PS-4 soil sample

Lead was recorded below detectable level at all the four sampling sites. The concentrations of Zinc were present in desirable limit in study area, Iron concentration in this study was 0.8, 2.2, 1.9 and 2.1 mg/kg respectively. Results revealed that concentration was within the desirable limit. Iron was quite higher in all the samples. Manganese, Boron and Cupper concentration in this study also found in desirable limit.

Bioaccumulation factor (BF) and transfer factor (TF)

Sample	BF (Shoot)	BF (Root)	BF (Plant)	TF
PS-1a	±0.01	±0.023	±0.2	±0.43
PS-2a	±0.01	±0.023	±0.2	±0.2
PS3-a	±0.02	±0.02	±0.2	±1
PS4-a	±0.1	±0.6	±0.3	±0.16

In this investigation, it has found that Phytoremediation technique is a low cost and eco-friendly. After using phytoextraction method of Phytoremediation heavy metals like Fe, Cu, Zn, Mo, Mn, B reduced 60-70% approximately. Phytoremediation is an eco friendly and green technology that utilizes the natural properties of plants to remediate to contaminated soil and water. Phytoremediation is a proposed as a cost effective plant based approach of environmental remediation. Heavy metals are contaminants that poses great environmental burden as they are harmful to livings and environment to large. In this study mustard plant used for remediate to contaminated soil of coal mining sites of Baikunthpur area Chhattisgarh by using Phytoremediation method.

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