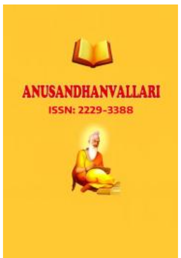

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Assessment of Infected Soil at Red Sandstone Mines and Impact on Vegetation of Contaminated Soil in Karauli District of Rajasthan

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Abstract- The proposed research paper focuses on evaluating the extent of soil contamination and its environmental impacts in the red sandstone mining areas of Karauli. It specifically aims to investigate how mining-induced pollution changes soil structure and affects vegetation health, as well as to explore sustainable methods of remediation and recovery. The main objective of this study is to assess the degree of soil contamination near red sandstone quarries and to determine how these contaminants – especially heavy metals and toxic substances – affect the composition, diversity and vitality of local vegetation. Furthermore, the research seeks to explore and evaluate viable solutions and removal technologies for soil contaminants, including phytoremediation, soil stabilization and washing methods, appropriate for the climatic and geological conditions of the Karauli region.

The research methodology will adopt a mixed approach combining field surveys, laboratory testing and statistical analysis. Soil and plant samples will be collected from major mine-affected sites Bhauapura-Ratiapura, Kasara, Chobe ki Guwari, Mokanpura-Berda,Bhakariand control sites such as Suroth in Karauli. Laboratory analyzes including Atomic absorption spectroscopy will be conducted to measure heavy metal levels and assess soil quality. The data will then be analyzed statistically to determine the relationship between pollution intensity and vegetation impact. Through this comprehensive methodological framework, the study aims to provide evidence-based insight into the environmental condition of the mining areas in Karauli.

The research is guided by the hypothesis that mining activities in the red sandstone quarries in Karauli have resulted in significant soil contamination with heavy metals and toxins, which has resulted in impaired vegetation health and poses potential risks to human and ecological well-being. This research has great environmental and socio-economic significance. By addressing the ecological consequences of mining, it contributes to the growing discussion about sustainable resource extraction and environmental protection. Soil pollution in Karauli threatens not only the integrity of local ecosystems, but also agricultural productivity and food security for the area's residents. Accumulation of toxic metals in crops and inhalation of dust particles can lead to long-term health problems, underscoring the urgency of scientific intervention and policy reforms. The results of this study are expected to assist in the design of regulatory guidelines and management strategies for sustainable mining, waste management and post-mining land reclamation.

Keywords: Infected soil assessment, red sandstone mines, soil contamination, heavy metals, vegetation impact, Karauli district.

I. INTRODUCTION

Karauli District, nestled within a sprawling expanse of 5,043 square kilometers (1,947 sq. mi), is strategically situated amidst a tapestry of neighboring regions, each adding its own unique essence to the district's cultural and geographical tapestry [1]. To the east lies the enchanting Dholpur district, while the northeast is adorned by the picturesque Bharatpur district. Meandering northward, Karauli shares its borders with the majestic Dausa district, and to the west, it finds kinship with the Sawai Madhopur district. Centrally positioned within this geographical marvel is Karauli City, a vibrant hub pulsating with history and culture, located at a junction of connectivity—169 km (105 mi) from the regal Gwalior, 114 km (71 mi) west of the iconic Agra, and 158 km (98 mi) southwest of the majestic Jaipur [2].

The Chambal River, a lifeline coursing through the landscape, gracefully delineates the southeastern boundary of the district, separating it from the state of Madhya Pradesh, approximately 5 kilometers (3.1 mi) from the quaint settlement of Mandrayal. Although hills and valleys gracefully adorn the district's terrain, Karauli is devoid of towering peaks, with the highest elevations scarcely surpassing 450 meters (1,480 ft) above sea level. Yet, despite this modest altitude, the landscape emanates an undeniable charm, captivating the hearts of all who traverse its paths [3-4].

One of the district's most cherished treasures lies in its substantial forest cover, which blankets an expansive area of 172,459 hectares (426,160 acres) as of the year 2011, is enveloping nearly 30% of the total geographical expanse, nurturing a rich ecosystem teeming with life. Within this verdant embrace, a diverse array of flora and fauna thrives, adding to the district's allure and ecological significance [5-6].

Karauli district is not only blessed with natural beauty but also boasts a wealth of mineral deposits, enhancing its economic potential and industrial significance. Among these valuable resources are sandstone, masonry stone, silica sand, soapstone, white clay, and traces of iron ore, each contributing to the district's economic vitality and industrial prowess [7]. The renowned Karauli sandstone, a testament to nature's artistry, graces the landscape in the form of majestic hill ranges that traverse the district's expanse [8]. These quarries, predominantly located in the vicinity of Karauli and Sapotra tehsils, yield sandstone of varying hues—ranging from rich reds to warm buffs-each imbued with a fine-grained texture and distinctive bedded formations, lending a timeless elegance to the architectural marvels crafted from its depths[9-10].

II. RESEARCH METHODOLOGY

Overview of mixed method approach

The mixed-methods approach used in this study is an integration of both quantitative and qualitative research methodologies. This approach is increasingly recognized for its ability to provide a more nuanced understanding of complex research questions by combining the strengths of both methods. In the context of assessing soil contamination's impact on vegetation, the mixed-methods approach allows for the triangulation of data, ensuring that the findings are not only robust but also reflective of both measurable outcomes and contextual nuances.

1. **Quantitative Research Methodology:-** Quantitative Research Methodology includesSampling Strategy**,** Laboratory Analysis, Data Analysis**.**
2. **Qualitative Research Methodology:-** Qualitative Research Methodology includes Field Observations,Ecological Assessments, STUDY AREA (Bhauapura-Ratiapura, Kasara, Chobe ki Guwari, Mokanpura-Berda and Bhakari and control sites such as Suroth in Karauli.), ENVIRONMENTAL AND ECOLOGICAL CHARACTERISTICS, SAMPLE COLLECTION.

HEAVY METAL ANALYSIS TECHNIQUES:-

Here's a detailed breakdown of the principles, procedures, and formulas for major heavy metal analysis techniques in soil, including all necessary technical details.

1. Atomic Absorption Spectroscopy (AAS)

- **Principle:**

Atoms in the ground state absorb light at specific wavelengths. The amount of absorbed light is proportional to the concentration of the element.

- **Procedure:**

Sample Digestion (e.g., HNO_3, HCl acid digestion)

Nebulization: Sample solution is atomized in a flame (FAAS) or graphite furnace (GFAAS).

Absorption Measurement: Radiation from a hollow cathode lamp is passed through the flame/furnace and measured.

- **Formula:**

$$A = 10\ \log(\frac{I_0}{I})$$

Where:

A = Absorbance

I_0= Intensity of incident light

I = Intensity of transmitted light

Calibration Curve used for concentration determination.

- **Advantages:**

High sensitivity, widely available, cost-effective for single-element analysis

- **Limitations:**

Limited to one element at a time (unless using multi-element AAS), requires sample digestion.

- **Metals Detected:**

Commonly used for Pb, Cd, Cu, Zn, Ni, Cr.

2. Graphite Furnace AAS (GFAAS)

- **Principle:**

Same as AAS, but uses electrothermal atomization for higher sensitivity

- **Procedure:**

Place a small volume (~10 µL) of sample in the graphite tube.

Use a programmed temperature cycle: drying → ashing → atomization → cleaning.

Measure absorbance during atomization.

- **Formula: Same as AAS**

3. Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES)

- **Principle:**

High-temperature plasma excites atoms; they emit light at characteristic wavelengths. Emission intensity is proportional to concentration.

- **Procedure:**

Digest the soil sample.

Atomize and excite using ICP (~7000 K).

Measure emission lines with optical detectors.

- **Formula:**

$$C = \frac{I_s - I_b}{m}$$

Where:

C= Concentration of element

Is = Signal intensity of sample

Ib = Background intensity

m = Slope of calibration curve

- **Advantages:**

Multi-element analysis, robust for complex matrices, good for higher concentration ranges.

- **Limitations:**

Less sensitive than ICP-MS for trace levels, higher detection limits.

- **Metals Detected:**

Suitable for Cu, Zn, Pb, Cd, Ni, Fe, etc

4. Inductively Coupled Plasma – Mass Spectrometry (ICP-MS)

- **Principle:**

Ionizes elements using plasma; measures mass-to-charge ratio of ions. Extremely sensitive for trace-level detection

- **Procedure:**

Sample digestion

Sample is nebulized, ionized in plasma.

Mass spectrometer separates ions by m/z.

Detectors count ions.

- **Formula:**

$$\text{Counts/sec} = \alpha \cdot C$$

Where:

α = Instrument sensitivity factor

C = Concentration

Internal standards used for accuracy.

- **Advantages:**

Multi-element analysis, robust for complex matrices, good for higher concentration ranges.

- **Limitations:**

Less sensitive than ICP-MS for trace levels, higher detection limits.

- **Metals Detected:**

Suitable for Cu, Zn, Pb, Cd, Ni, Fe, etc

5. X-ray Fluorescence (XRF)

- **Principle:**

High-energy X-rays eject inner-shell electrons. Outer electrons fill the vacancy, emitting fluorescent X-rays characteristic of each element.

- **Procedure:**

Dry, grind, and pelletize soil.

Analyze using handheld or bench-top XRF.

Compare spectral lines with standards.

- **Formula:**

$$I=K\cdot C$$

Where:

I = Intensity of characteristic X-ray

C = Element concentration

K = Calibration constant

- **Advantages:**

Non-destructive, rapid, minimal sample preparation, portable for field use

- **Limitations:**

Lower sensitivity for trace metals, surface analysis only, matrix effects

- **Metals Detected:**

Pb, As, Cu, Zn, Cr, Cd, and others

6. Cold Vapor AAS (CV-AAS) for Mercury

- **Principle:**

Mercury is reduced to vapor form using $SnCl_2$ or $NaBH_4$, and vapor absorbs UV light at 253.7 nm.

- **Procedure:**

Digest sample.

Reduce Hg^{2+} to Hg^0 vapor.

Pass through absorption cell.

Measure absorbance

- **Formula:**

Same absorbance formula as AAS

- **Common Digestion Procedures**

Acid Digestion (USEPA 3050B):

HNO_3 and H_2O_2 for organic matrix

Add HCl to dissolve residual metals.

Heat until clear solution.

Aqua Regia Digestion:

Mix 3:1 HCl:HNO_3

Reflux sample for 2 hours.

Microwave-Assisted Digestion (USEPA 3051A):

HNO_3 + HCl inside sealed microwave vessels.

Faster, better pressure/temp control.

Calibration and Quantification

Limit of Detection (LOD):

$$LOD = \frac{3XSD_{blanks}}{\text{slope of calibration curve}}$$

Standard References & Guidelines

USEPA Methods: 3050B (acid digestion), 6010C (ICP-OES), 6020B (ICP-MS)

ISO 11047 (AAS), ISO 11466 (ICP)

BIS Soil Test Methods (India)

III. METAL EXTRACTION FROM COLLECTED SOIL SAMPLES

The metal extraction process aims to isolate heavy metals from soil samples for subsequent analysis. The procedure ensures that metals bound in the soil matrix are released into a solution, which can be quantified using spectroscopic methods.

Procedure:

1. **Sample Preparation:**

Air-dried soil samples were ground to pass through a 2 mm sieve. Approximately 1 gram of the sieved soil was used for the extraction process.

2. **Acid Digestion:**

The soil sample was placed in a Teflon digestion vessel. A mixture of concentrated nitric acid (HNO_2) and hydrochloric acid (HCl) in a ratio of 3:1 was added to the sample. This mixture, known as Aqua Regia, effectively dissolves most metals.

The digestion vessel was heated at 95°C for 2 hours to ensure complete digestion of the soil. The sample was then allowed to cool to room temperature.

3. **Filtration and Dilution:**

The digested sample was filtered using Whatman filter paper to remove any remaining solid particles. The filtrate, which contains the extracted metals, was collected.

The filtrate was then diluted with deionized water to a known volume (usually 50 or 100 mL) for analysis.

4. **Storage:**

The diluted extract was stored in clean polyethylene bottles at 4°C until analysis. This prevents any changes in the concentration of metals in the extract.

5. **Analysis:**

The metal content of the extract was analyzed using Atomic Absorption Spectroscopy (AAS), which quantifies the concentration of specific metals based on their absorption spectra.

IV. DATA ANALYSIS

SOIL AND PLANT SAMPLE COLLECTION

Soil and vegetation samples have been collected from the affected areas near Red Sandstone mines and from control areas. The collected data is as follows:

Table 1: Sample names Collected from Different Area

S.NO	Area Name	Sample
1	Bhauapura-Ratiapura	SS-1,SS-2, SS-3
2	Kasara	SS-4, SS-5, SS-6
3	Chobe ki Guwari	SS-7, SS-8
4	Mokanpura-Berda	SS-9,SS10
5	Bhakari	SS-11, SS-12,SS-13
6	Suroth (Karauli)	SS-14, SS-15

SOIL ANALYSIS:-

Table 2: Average Heavy Metal Concentration

Area Name	Average Heavy Metal Concentration (mg/kg)
Bhauapura-Ratiapura	200
Kasara	180
Chobe ki Guwari	220
Mokanpura-Berda	210
Bhakari	250
Suroth (Karauli)	50

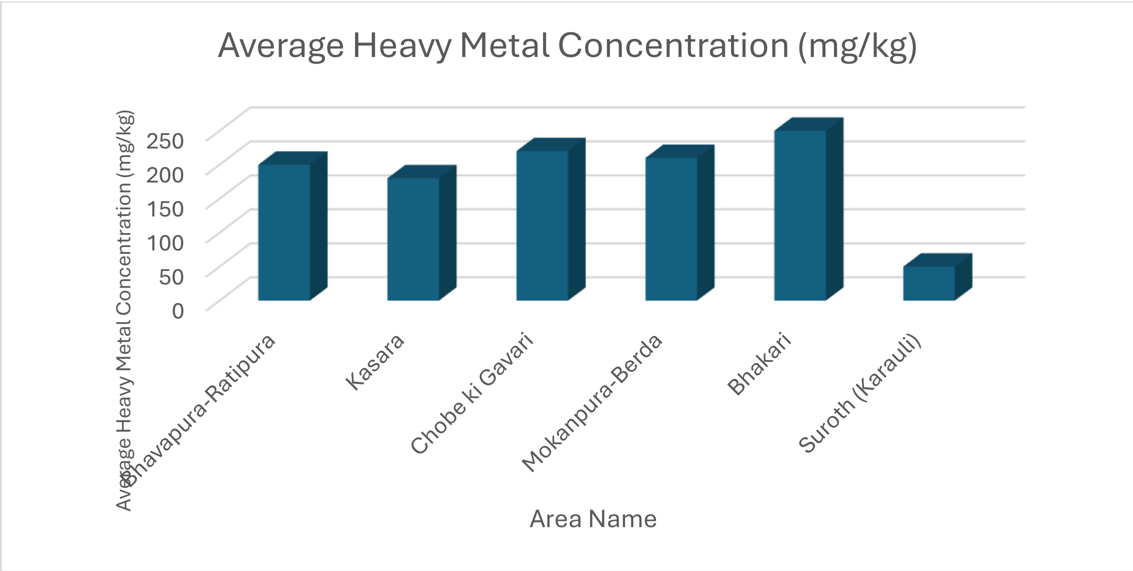


Figure 1: Average Heavy Metal Concentration

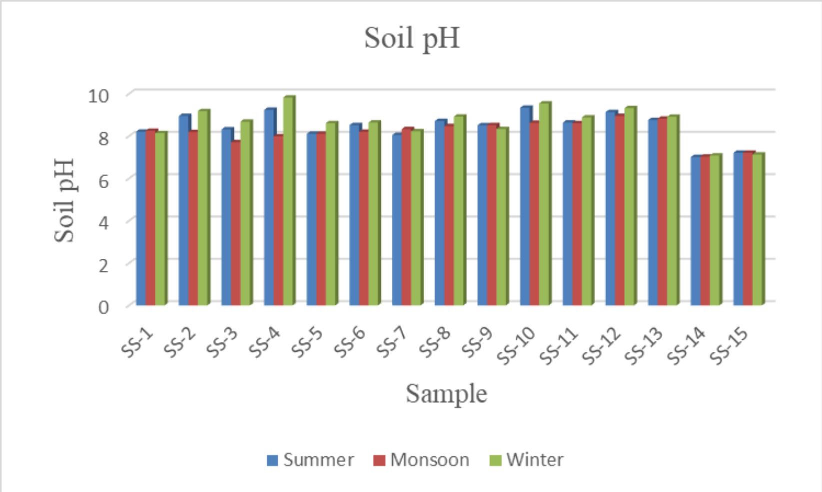
Soil pH

pH of the soil is an important parameter as it impacts the mobility and accessibility of metals in soil. The soils under study in present research the pH of soil samples from all sites and for all seasons was found too slightly alkaline. Measure of pH for all samples was in range of 7.01 to 9.82.

Table 3: Soil pH

S. No.	Samples	Summer	Monsoon	Winter
1	SS-1	8.21	8.25	8.14
2	SS-2	8.95	8.19	9.18
3	SS-3	8.32	7.71	8.68
4	SS-4	9.24	7.99	9.82
5	SS-5	8.11	8.11	8.61
6	SS-6	8.52	8.2	8.64
7	SS-7	8.05	8.33	8.23
8	SS-8	8.71	8.47	8.92
9	SS-9	8.51	8.52	8.33
10	SS-10	9.34	8.63	9.54
11	SS-11	8.64	8.61	8.88

12	SS-12	9.13	8.95	9.32
13	SS-13	8.76	8.82	8.91
14	SS-14	7.01	7.03	7.08
15	SS-15	7.21	7.21	7.13



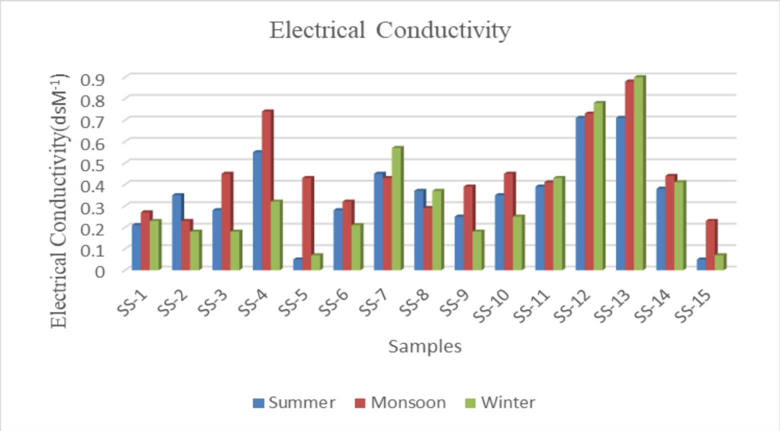
Electrical Conductivity

The measure for the study of soluble salt content of soil is called electrical conductivity. The cations (Na+, K+, Ca2+ and Mg2+) and ions such as Cl-, SO4-2 Along with CO3-2 etc. are the main materials that have been estimated in the study electric conductivity. The study of these materials gives a rough idea about the salinity of the soil.

Table 4: Electrical Conductivity

S. No.	Samples	Summer	Monsoon	Winter
1	**SS-1**	0.21	0.27	0.23
2	**SS-2**	0.35	0.33	0.18
3	**SS-3**	0.28	0.45	0.18
4	**SS-4**	0.55	0.74	0.32
5	**SS-5**	0.15	0.43	0.07
6	**SS-6**	0.28	0.32	0.21

7	**SS-7**	0.45	0.43	0.57
8	**SS-8**	0.37	0.29	0.37
9	**SS-9**	0.25	0.39	0.18
10	**SS-10**	0.35	0.45	0.25
11	**SS-11**	0.39	0.41	0.43
12	**SS-12**	0.71	0.73	0.78
13	**SS-13**	0.71	0.88	0.91
14	**SS-14**	0.38	0.44	0.41
15	**SS-15**	0.05	0.23	0.07



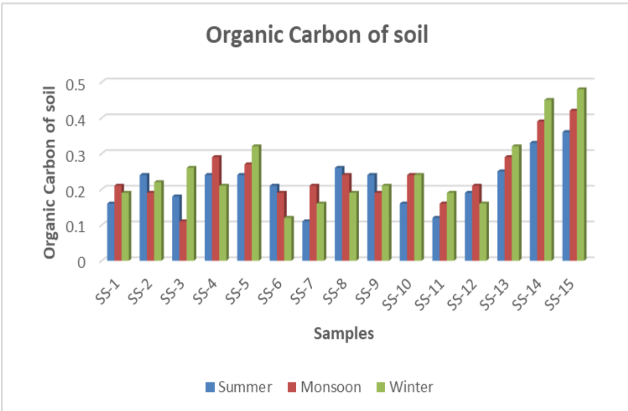
Organic Carbon

For summer season: the OC values varied from 0.11 to 0.36 with*i*n average value 0.21. In sample SS7 minimum value of OC was observed and in sample SS15 maximum value of OC was observed.

Table 5: Organic Carbon of Soil

S. No.	Samples	Summer	Monsoon	Winter
1	SS-1	0.16	0.21	0.19
2	SS-2	0.24	0.19	0.22
3	SS-3	0.18	0.11	0.26
4	SS-4	0.24	0.29	0.21

5	SS-5	0.24	0.27	0.32
6	SS-6	0.21	0.19	0.12
7	SS-7	0.11	0.21	0.16
8	SS-8	0.26	0.24	0.19
9	SS-9	0.24	0.19	0.21
10	SS-10	0.16	0.24	0.24
11	SS-11	0.12	0.16	0.19
12	SS-12	0.19	0.21	0.16
13	SS-13	0.25	0.29	0.32
14	SS-14	0.33	0.39	0.45
15	SS-15	0.36	0.42	0.48



HEAVY METAL IN AGRICULTURAL SOIL

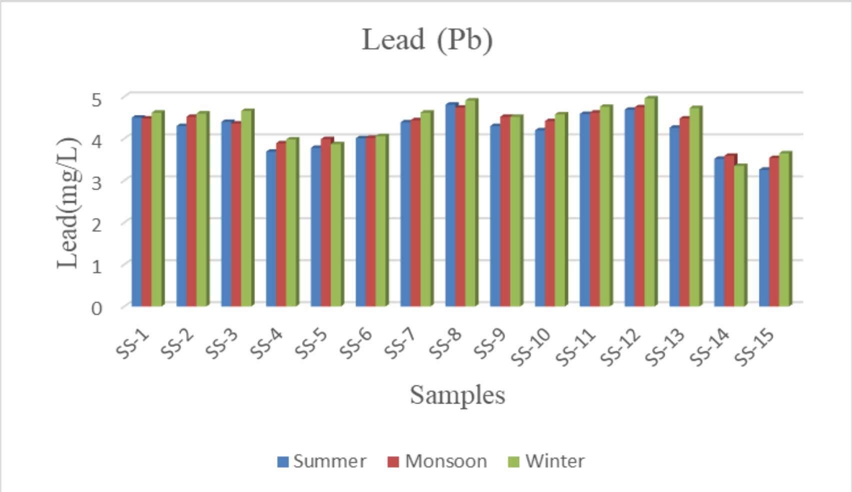
Lead (Pb)

For summer season: the Pb concentration ranged between 3.26 to 4.81 mg/L. The average concentration of Pb was 4.18 mg/L. The minimum value of Pb was monitored in sample SS15. The maximum value of Pb was viewed in sample SS13.

Table 6: Lead (Pb)

S. No.	Sites	Summer	Monsoon	Winter
1	**SS-1**	4.51	4.48	4.62
2	**SS-2**	4.31	4.52	4.62
3	**SS-3**	4.41	4.36	4.66

4	**SS-4**	3.69	3.89	3.98
5	**SS-5**	3.78	3.99	3.87
6	**SS-6**	4.01	4.02	4.06
7	**SS-7**	4.39	4.44	4.62
8	**SS-8**	4.80	4.74	4.91
9	**SS-9**	4.31	4.52	4.52
10	**SS-10**	4.21	4.42	4.58
11	**SS-11**	4.59	4.62	4.76
12	**SS-12**	4.69	4.75	4.96
13	**SS-13**	4.81	4.48	4.73
14	**SS-14**	3.52	3.59	3.35
15	**SS-15**	3.26	3.54	3.65



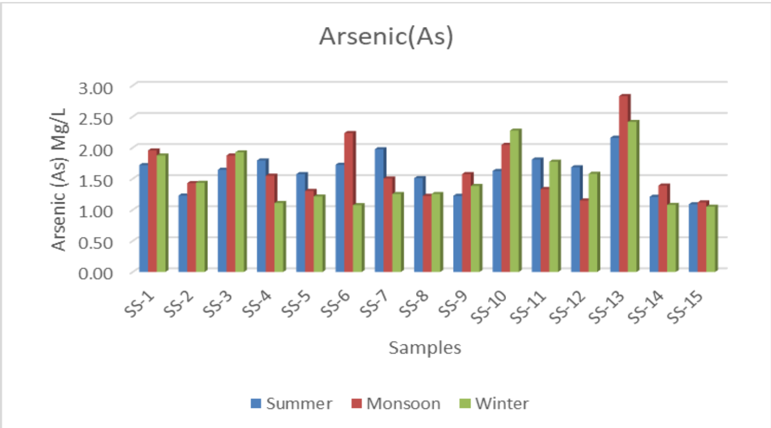
Arsenic (As)

Table 7: Arsenic (As)

S. No.	Sites	Summer	Monsoon	Winter
1	**SS-1**	1.72	1.96	1.88
2	**SS-2**	1.23	1.43	1.44
3	**SS-3**	1.65	1.88	1.93
4	**SS-4**	1.80	1.55	1.11

5	**SS-5**	1.58	1.31	1.22
6	**SS-6**	1.73	2.24	1.08
7	**SS-7**	1.98	1.51	1.26
8	**SS-8**	1.51	1.23	1.26
9	**SS-9**	1.23	1.58	1.39
10	**SS-10**	1.63	2.05	2.28
11	**SS-11**	1.81	1.34	1.78
12	**SS-12**	1.69	1.15	1.58
13	**SS-13**	2.16	2.83	2.42
14	**SS-14**	1.21	1.39	1.08
15	**SS-15**	1.09	1.12	1.05

For summer season: the mean data table reveals that the As concentration varied from 1.09 to 2.16 mg/L. and this range were above the standard parameters. The minimum concentration of As was found in sample SS15. The maximum concentration of As was examined in sample SS13. The average concentration of As was 1.78 mg/L.



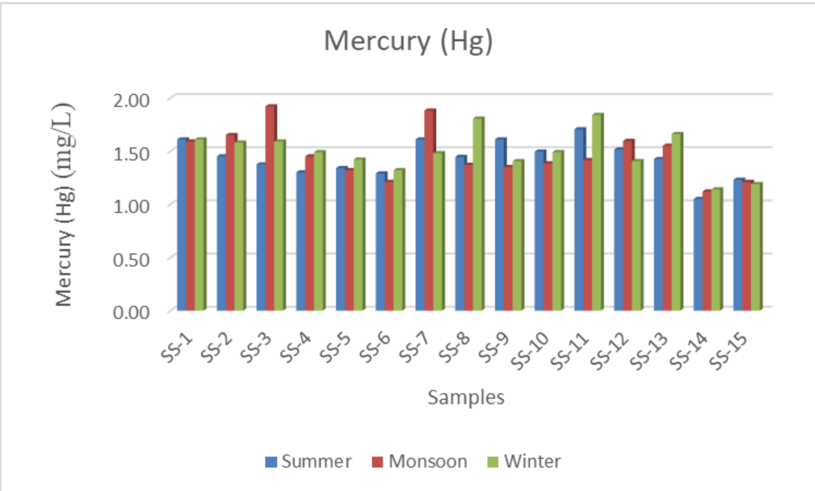
Mercury (Hg)

For summer season: the Hg concentration ranged between 1.05 and 1.71 mg/L. The average concentration of Hg was 1.43 mg/L. The minimum value of Hg was monitored in sample SS14. The maximum value of Hg was viewed in sample SS11.

Table 8: Mercury (Hg)

S. No.	Sites	Summer	Monsoon	Winter
1	**SS-1**	1.61	1.59	1.61

2	**SS-2**	1.45	1.65	1.58
3	**SS-3**	1.38	1.92	1.59
4	**SS-4**	1.30	1.45	1.49
5	**SS-5**	1.34	1.92	1.42
6	**SS-6**	1.29	1.21	1.32
7	**SS-7**	1.61	1.88	1.48
8	**SS-8**	1.45	1.37	1.81
9	**SS-9**	1.61	1.35	1.41
10	**SS-10**	1.50	1.39	1.49
11	**SS-11**	1.71	1.92	1.84
12	**SS-12**	1.52	1.60	1.41
13	**SS-13**	1.43	1.55	1.66
14	**SS-14**	1.05	1.12	1.14
15	**SS-15**	1.23	1.21	1.19



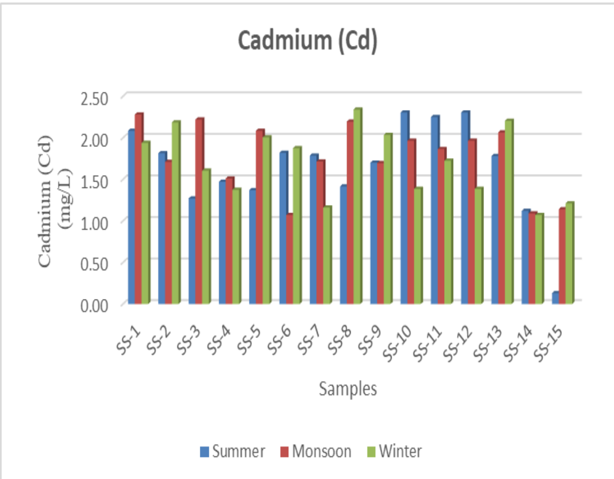
Cadmium (Cd)

For summer season: the Cd concentration ranged between 1.12 to 2.31 mg/L. The average concentration, Cd was 1.71 mg/L. The minimum value of Cd was monitored in sample SS14. The maximum value of Cd was viewed in sample SS10.

Table 9: **Cadmium (Cd)**

S. No.	Sites	Summer	Monsoon	Winter
1	**SS-1**	1.79	1.72	1.16
2	**SS-2**	1.82	1.71	2.19

3	**SS-3**	1.27	2.22	1.61
4	**SS-4**	1.47	1.51	1.38
5	**SS-5**	1.37	2.09	2.01
6	**SS-6**	1.82	1.07	1.88
7	**SS-7**	2.09	2.28	1.94
8	**SS-8**	1.42	2.20	2.34
9	**SS-9**	1.70	1.70	2.04
10	**SS-10**	2.31	1.97	1.39
11	**SS-11**	2.25	1.87	1.73
12	**SS-12**	2.31	1.97	1.39
13	**SS-13**	1.78	2.07	2.21
14	**SS-14**	1.12	1.09	1.07
15	**SS-15**	1.13	1.14	1.21



VEGETABLE ANALYSIS

Heavy metals in vegetables

Vegetables samples of Cabbage, Onion, Garlic, Brinjal, Tomato, Redchilli, Pea, Cauliflower, Radish, Carrot and Spinach (Betavulgaris L) were collected from agricultural sites, to study the heavy metals (Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Cd and Pb) concentration. These agricultural sites were same from where the agricultural soil samples were taken. Leafy vegetables were favored for sampling because earlier research suggests that they accumulate heavier metals than other vegetables (Jinadasa et al. 1997).

Result of various heavy metals in different vegetable samples are represented in table 10.

Table 10: Heavy Metals in Vegetables

S. No.	Vegetables	Cd	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Se	Pb
1	**Cabbage**	0.13	4.24	24.08	144.71	0.19	2.03	30.61	59	3.13	2.24	8.3
2	**Onion**	0.09	8.26	33.46	315.46	0.3	3.37	6.22	68.57	0.11	0.19	1.37
3	**Garlic**	0.55	8	18.01	272.42	0.22	3.01	17.74	67.84	0.16	0.14	2.52
4	**Brinjal**	0.29	13.6	17.25	209.6	0.3	6.35	99.56	73.82	0.07	0.099	23.7
5	**Tomato**	0.39	4.62	16.82	151.28	0.24	2.78	12.48	39.91	0.07	0.3	1.6
6	**Red chilli**	0.34	5.67	17.33	197.79	0.31	5.13	30.06	92.57	0.32	0.62	1.8
7	**Pea**	0.01	1.19	14.22	73.43	0.12	1.26	10.46	51.56	1.46	1.77	0.08
8	**Cauliflower**	0.68	1.42	30.73	133.84	0.26	1.07	6.84	59.84	0.04	0.14	1.52
9	**Radish**	0.55	3.01	18.59	231.91	0.25	1.05	5.28	45.99	0.11	0.078	0.58
10	**Carrot**	0.16	2.74	22.76	144.32	0.12	1.02	5.45	36.85	0.07	0.104	0.29
11	**Spinach**	2.84	2.52	140.1	487.04	0.37	1.6	14.77	52.18	0.22	0.27	0.96
	MEAN	**0.55**	**5.02**	**32.12**	**214.71**	**0.24**	**2.61**	**21.77**	**58.92**	**0.524**	**0.54**	**3.88**
	MAX	**2.84**	**13.6**	**17.25**	**487.04**	**0.37**	**6.35**	**92.57**	**73.82**	**3.13**	**2.24**	**23.7**
	MIN	**0.01**	**1.19**	**14.22**	**73.43**	**0.12**	**1.02**	**5.28**	**36.85**	**0.04**	**0.08**	**0.08**

Table 11: Vegetation Assessment

Area Name	Biodiversity Index	Average Plant Height (cm)	Leaf Chlorophyll Content
Bhauapura-Ratiapura	1.2	25	20
Kasara	1.3	30	22
Chobe ki Guwari	1.1	20	18

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Mokanpura-Berda	1.2	22	19
Bhakari	1	18	15
Suroth (Karauli)	2.5	60	35

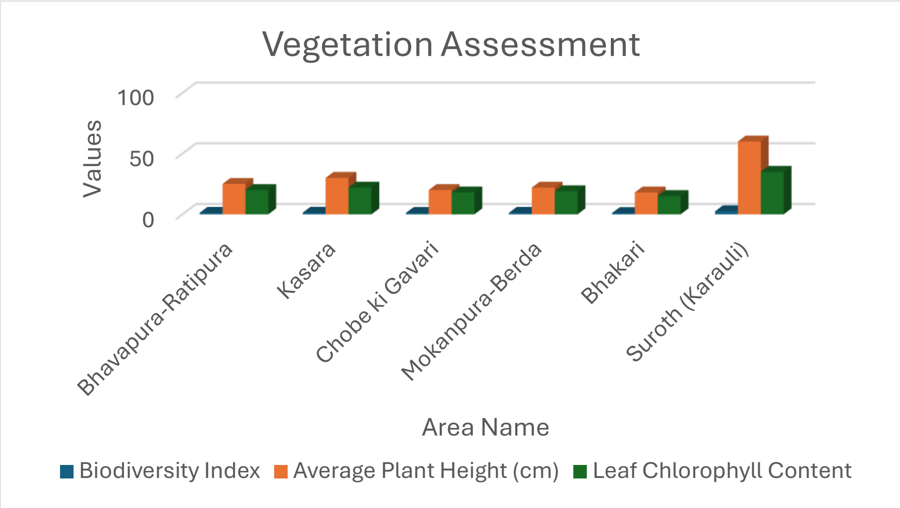

Figure 2: Vegetation Assessment

The bar graph below visualizes theVegetation Assessment in different areas:

V. RESULTS & DISCUSSION

CONTAMINATION INDEX IN DIFFERENT AREAS

The table below presents the collected data for the contamination index in different areas:

Table 12: Site wise Contamination Index

Area Name	Contamination Index
Bhauapura-Ratiapura	2.0
Kasara	1.8
Chobe ki Guwari	2.2
Mokanpura-Berda	2.1
Bhakari	2.5
Suroth (Karauli)	0.5

The bar graph below visualizes the contamination index in different areas:

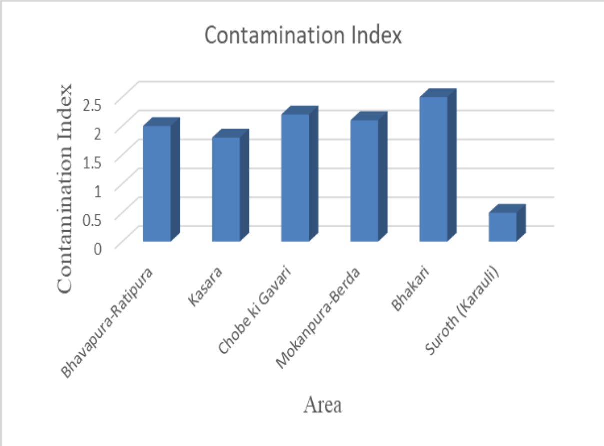

Figure 3 : Contamination Index in Different Areas

Interpretation:

- Bhakari has the highest contamination index at 2.5, indicating the highest level of soil contamination among the areas evaluated.
- Suroth (Karauli) (Karauli), the control area, has the lowest contamination index at 0.5, indicating minimal soil contamination.

DETERMINATION OF HEAVY METALS IN SOIL BY AAS:-

Flame atomic absorption spectrometer (FAAS) is a suitable technique for determining metals at parts per million (ppm) concentration levels with good precision. FAAS requires an oxidant gas in addition to fuel gas to support combustion. Samples are introduced into the atomizer as an aerosol by the nebulizer. FAAS technique provides fast analysis of 10-15s per sample, with very good precision (repeatability), moderate interferences that can be easily corrected, and relatively low cost. FAAS was successfully applied for the determination of heavy metals in various matrices (Helaluddin et al., 2016). The AAS Operating Conditions for Selected Heavy Metals are illustrated in Table 5.

Table 13: AAS Operating Conditions for Selected Heavy Metals

Element	Wavelength (nm)	Flame Type	Slit Width (nm)	Lamp Current (mA)
Zn (Zinc)	213.9	Air–Acetylene	1.0	5.0
As (Arsenic*)	193.7	Hydride–Air–Acetylene (HGAAS)	0.5	10.0
Cd (Cadmium)	228.8	Air–Acetylene	0.5	4.0

Cr (Chromium)	357.9	Air–Acetylene	0.2	7.0
Hg (Mercury*)	253.7	Cold Vapor AAS (CV-AAS)	0.5	4.0
Pb (Lead)	283.3	Air–Acetylene	0.5	10.0
Cu (Copper)	324.8	Air–Acetylene	0.5	3.0
Ni (Nickel)	232.0	Air–Acetylene	0.2	4.0

AAS SPECTRUM FOR HEAVY METALS AT ALL SELECTED SITES:-

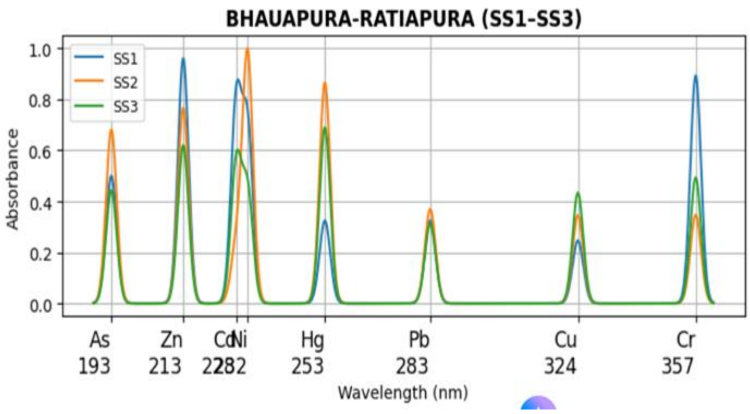

Figure 4: AAS Spectrum for Bhauapura-Ratiapura

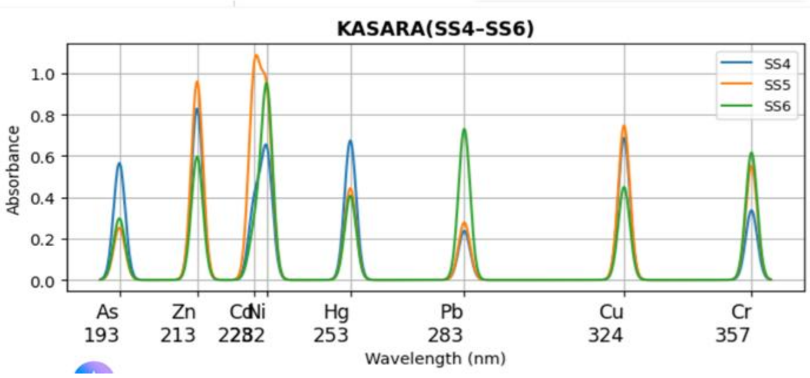

Figure 5: AAS Spectrum for Kasara

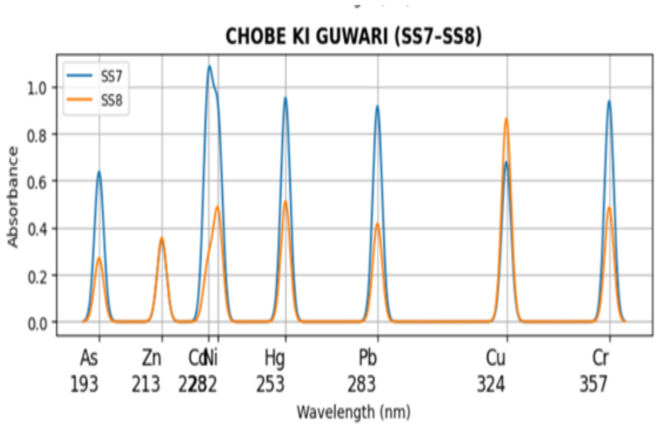

Figure 6: AAS Spectrum for Chobe ki Guwari

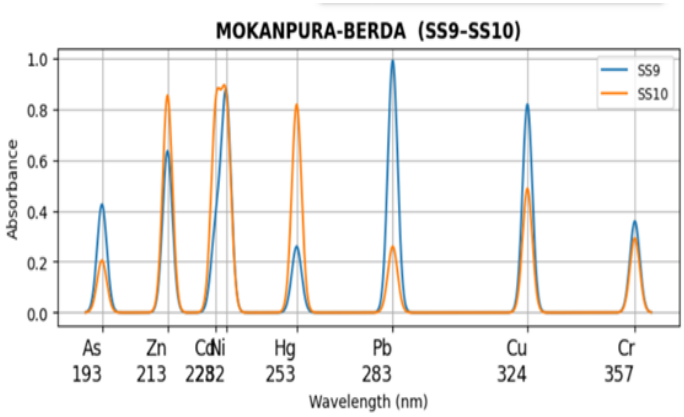

Figure 7: AAS Spectrum for Mokanpura-Berda

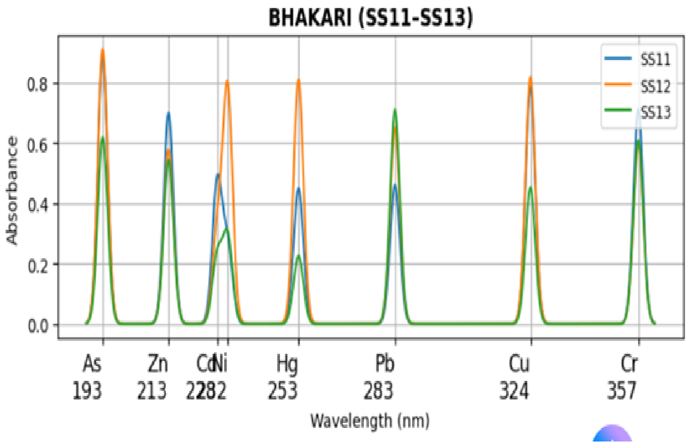

Figure 8: AAS Spectrum for Bhakari

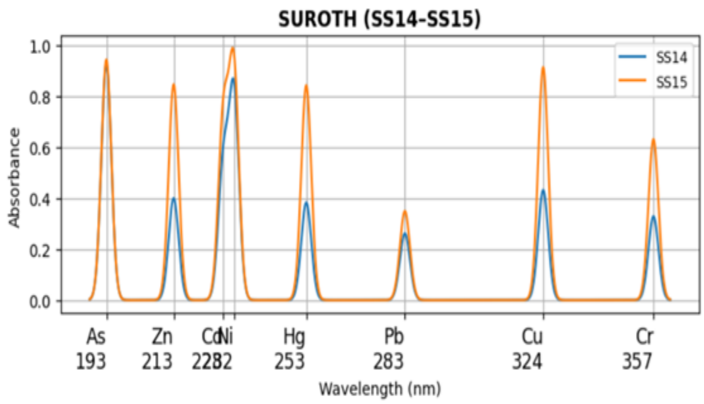

Figure 9: AAS Spectrum for Suroth (Karauli)

VI. CONCLUSION

The article aimed to investigate the effects of mining activities on soil contamination and its subsequent impact on vegetation in the affected areas. This conclusion section synthesizes the findings, discusses their implications, and provides recommendations for future research and practical interventions.

The research primarily focused on assessing the concentration of heavy metals in soil samples collected from various locations near Red Sandstone mines and their impact on local vegetation. The study involved both field and laboratory analyses to measure heavy metal concentrations and evaluate the health and biodiversity of vegetation in the affected areas.

Soil Contamination

The study revealed significant contamination of soil with heavy metals in areas surrounding the Red Sandstone mines. Key findings include:

- Bhakari has the highest contamination index at 2.5, indicating the highest level of soil contamination among the areas evaluated.
- Suroth (Karauli) (Karauli), the control area, has the lowest contamination index at 0.5, indicating minimal soil contamination.
- Bhakari has the highest average heavy metal concentration of 250mg/kg.
- Suroth (Karauli), the control area, has the lowest average heavy metal concentration of 50mg/kg.

Impact on Vegetation

The health and biodiversity of vegetation were adversely affected in the contaminated areas. Key observations include:

- **Biodiversity Index:**Suroth (Karauli)had the highest biodiversity index (2.5), indicating healthier vegetation, whereas Bhakari had the lowest (1.0), indicating reduced plant species diversity.
- **Average Plant Height:** The control area Suroth (Karauli) exhibited the highest average plant height (60 cm), while Bhakari had the shortest average plant height (18 cm), suggesting stunted growth due to soil contamination.
- **Leaf Chlorophyll Content:**Suroth (Karauli) showed the highest leaf chlorophyll content (35), indicating better plant health, whereas Bhakari had the lowest chlorophyll content (15), suggesting poor plant health.
- The performance and stability of power systems where high-quality electrical output is essential.

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