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## ORIGINAL ARTICLE

# Evaluation of soil properties and lead content in agricultural soils of Gwalior

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**ABSTRACT**
*Soil properties and lead content in agricultural soils from rural areas of Gwalior at ten different sites were assessed. Soil properties analysed were pH, conductivity, texture and water holding capacity. Soils of croplands were slightly alkaline, pH ranged from 7.12 to 7.41, conductivity ranged from 0.35 mS/cm to 0.52 mS/cm and water holding capacity ranged from 47.1% to 58.4%. Soil texture was variable at different sites, sand content ranged from 34.0% to 45.6 %, clay 39.0 % to 45.4 % and silt content was low ranged from 14.8% to 20.6%. Lead content was found higher at surface soil in comparison to 15 cm depth at all the ten sites. Lead content in surface soil ranged from 4.5 mg/kg to 9.5 mg/kg and lead content in soil at depth of 15 cm ranged from 3.1mg/kg to 6.5 mg/kg. The three sites Bela ki babdi, Nayagoan and Panihar had high lead content both in surface soil (8.6 mg/kg- 9.5 mg/kg) and at the depth of 15 cm (6.1 mg/kg-6.5mg/kg).The study revealed that the lead content in soil decreased with depth from soil surface.The lead content fluctuated in soil, after application of fertilizers and manure in the field, the lead content in soil showed appreciable enhancement which indicated that fertilizers and manure were contaminated with lead and added lead load to soil.*
***Key words:-*** *Soil properties, contamination, heavy metal, lead, soil texture, agricultural soils*

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## INTRODUCTION

Soil productivity is dependent on physical, chemical and biological characteristics of soil. These soil characteristics are influenced by land uses and help in restoration of soil quality [1]. Pollution of soil by heavy metals is wide spread all over world [2] due to agricultural, industrial, mining, transport, waste disposal and other anthropogenic activities [3] and is critical factor for safety of food world wide [4]. Contaminated soils have several negative impacts on environment including degradation of water quality, decrease in crop yield and crop quality. Heavy metals in food chain is hazardous for human health [5]. Soil is major sink for metals released into the environment.

Heavy metals accumulate in top soil [6], and then enters into crop plants and fodder plants and may accumulate in human tissues by the process of biomagnification [7]. Factors gorverning heavy metal content in crop plants are soil properties, water quality, climatic parameters, agrochemical application, plant uptake and plant parts [8]. The heavy metal content in arable soils is affected by soil characteristics and cropping practices [9]. The inorganic metal composition of soil depends on both natural and anthropogenic factors. Solublity of metals is influenced by pH of soil, redox potential, complexing agents such as carbonates, sulphates, chlorides and organic acids [10, 11]

Lead (Pb) is a major heavy metal pollutant in water and soil. Anthropogenic sources of lead are from industries, mininig and smelting of lead ores, metal plating, fertilizers, pesticides, effluents of storage batteries, lead containing paints and explosives, municipal sewage sludges [12]. Lead has been widely used as additive in gasoline in last century and has been phased out all over world now.

Increase in lead content of agricultural soils has been found near industrial areas and high ways. Sewage sludge contains heavy metals including lead is discharged into field and garden soils due to increased urbanization [13]. Average Pb concentration for surface soils worldwide is 32 mg/kg and ranges from 10

to 67 mg/kg [14]. The lead concentration in polluted soils may range upto 400-800 mg/kg soil [15]. In certain soil types, depending on geology, the heavy metals may be higher than common range [16, 17].
There is scanty data available about lead content in soils of Gwalior. This study evaluates the lead content in soils of agricultural fields in rural areas of Gwalior and also assesses physical and chemical characteristics of soils. This survey of lead in agriculture soils of Gwalior is the first attempt in this region which will be hepful in monitoring and remediation of soil.

## MATERIAL AND METHODS

**Study area**: Gwalior is one of the district of Madhya Pradesh, India. It is located at latitude of 26°21'N and Longitude 78°18'E. The climate is semi arid to sub humid summer with an average temperature of 40.5°C, cool and dry winter with average winter temperature of 6.6°C. The average annual rainfall is 91 cm and most of it occurs during rainy season. Two main crop seasons are Kharif (rainy season) and Rabi (winter season), Kharif crops grown are Maize (*Zea mays*), Sorghum (*Sorghum bicolor*), Pearl millet (*Pennisetum glaucum*) and Rabi crops grown are Wheat (*Triticum aestivum*), Mustard (*Brassica campestris*), and Gram (*Cicer arietinum*).
**Study sites:** Ten sites were selected for this study and all sites are agricultural fields in the rural areas of Gwalior, Madhya Pradesh India. Modern agricultural practices include extensive use of agrochemicals, fertilizers, weedicides, fungicides, insecticides. The sites are shown in table I and figure 1.

**Table 1. List of study sites of Gwalior**

| Site No. | Name of site | Crops Cultivated | Site No. | Name of Site | Crops cultivated |
|---|---|---|---|---|---|
| 1 | Rairu | Sorghum/ Wheat /Mustard | 6 | Samudan | Maize/ Wheat |
| 2 | Jalalpur | Sorghum/ Wheat /Mustard | 7 | Dabra | Pearl millet / Wheat |
| 3 | Baretha | Maize/ Wheat | 8 | Bela ki babdi | Sorghum / Wheat/ Mustard |
| 4 | Tilori Malanpur | Pearl millet/Wheat/Gram | 9 | Nayagoan | Pearl millet / Wheat |
| 5 | Jurasi | Sorghum /Wheat | 10 | Panihar | Pearl millet / Wheat |

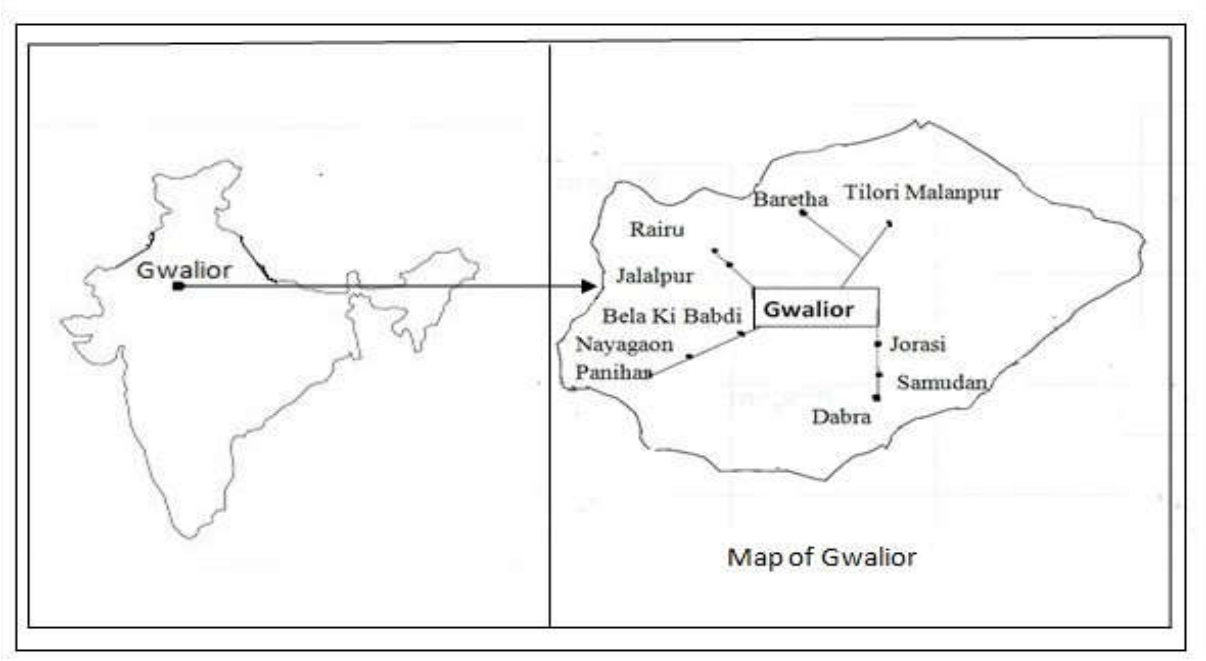


**Figure 1** Map of Gwalior showing location of study sites.

**Soil samples:** Soil samples were taken from agriculture fields. Plant residues, litter, rootlets, etc were removed from soil surface, thereafter soil samples were collected by using soil augers. Soil samples in triplicate were collected in plastic bags at the top soil surface and 15 cm. depth & were sealed and labelled. Soil samples were air dried in laboratry by spreading evenly on paper sheets. The big lumps were broken down and plant residues and other undesirable matter were removed. Soil was homogenised and passed through a 2mm. mesh screen.

**Soil pH and Electrical conductivity:** 20 gm. of soil (Particle size < 2mm) was taken in a beaker and 50 ml of distilled water was added (soil: water ratio of 1:2.5). The suspension was shaken for one hour at ratory shaker as described by [18]. Soil suspension was filtered. The pH of filtrate was determined by using digital pH meter (Systronics make, type 335). Electrical conductivity was measured by conductivity meter (Systronics make, model 304)

**Soil texture and water holding Capacity:** Texture of soil was determined by hydrometer method [19]. Water holding capacity of soil was determined by method suggested by [20].

**Determination of lead metal :** Heavy metal lead was extracted by acid digestion method. 1gm of air dried soil <2 mm was taken and mixed with 15 ml of aqua regia (HCl: $HNO_3$ in 3:1ratio) and heated in a hot plate at temperature of $100^{o}$C in digestion chamber for 3-4 hours till translucent solution was obtained [21] which indicates the completion of digestion process. Digested samples were cooled, and filtered. Filtrate was diluted with double distilled water and final volume made upto 30 ml. Analysis of lead was done by using Atomic Absorption Spectrophotometer (GBC Scientific Equipment Ltd. Australia model NB14).

## RESULTS

The physical and chemical characteristics of soils studied are given in tables 2

**Soil pH and Conductivity:** The pH of soils ranged from 7.12±0.11 to 7.41± 0.24 that indicated the soils were alkaline. The soils of sites 8,9,10 were slightly alkaline and pH ranged from 7.12± 0.11 to 7.16± 0.15 in comparison to sites 1-7 which had pH in the range of 7.24± 0.31- 7.41±0.24. Electrical conductivity ranged from 0.35±0.053mS/cm to 0.52±0.065 mS/cm.

**Soil texture:** Variation in soil texture at various sites had been found. In sites 1- 4, the soil was sandy loam and in sites 5-10 soil was clay loam. Proportion of sand ranged from 34.0±3.6% to 45.6± 3.2% and clay was in range of 39.0± 3.4% - 45.4± 2.7 % and silt was in range of 14.8± 1.5%- 20.6± 2.6 %.

**Table 2. Characteristics of soil at various sites in rural areas of Gwalior**

| Site No. | Name of site | Soil pH | Soil Conductivity mS/cm | Texture of soil | | | Water holding capacity (%) |
|---|---|---|---|---|---|---|---|
| | | | | Sand % | Silt % | Clay % | |
| 1 | Rairu | 7.27±0.21 | 0.46±0.051 | 44.5±2.6 | 16.4±2.4 | 39.1±1.2 | 47.1±3.2 |
| 2 | Jalalpur | 7.36±0.29 | 0.48 ±0.072 | 45.0±2.0 | 14.8±1.5 | 40.2±2.6 | 48.4±2.7 |
| 3 | Baretha | 7.28±0.27 | 0.42±0.043 | 43.2±1.8 | 16.7±2.1 | 40.1±2.3 | 49.3±2.9 |
| 4 | Tilori Malanpur | 7.34±0.31 | 0.43±0.061 | 45.6±3.2 | 15.4±3.1 | 39.0±3.4 | 48.6±3.4 |
| 5 | Jurasi | 7.24±0.31 | 0.37±0.045 | 39.8±2.7 | 18.0±2.7 | 42.2±3.7 | 52.2±3.1 |
| 6 | Samudan | 7.31±0.21 | 0.35±0.053 | 39.3±3.2 | 19.1±3.2 | 41.6±3.5 | 54.4±3.9 |
| 7 | Dabra | 7.41±0.24 | 0.38±0.058 | 38.8±2.9 | 19.4±2.5 | 41.8±3.3 | 55.2±3.8 |
| 8 | Bela ki Babdi | 7.12±0.11 | 0.51±0.052 | 34.6±2.8 | 20.2±1.4 | 45.2±3.1 | 58.4±2.7 |
| 9 | Naya Goan | 7.15±0.17 | 0.52±0.065 | 35.8±3.1 | 19.4±2.1 | 44.8±3.9 | 58.2±3.5 |
| 10 | Panihar | 7.16± 0.15 | 0.49±0.067 | 34.0±3.6 | 20.6±2.6 | 45.4±2.7 | 54.6±3.6 |

**Water holding capacity**: Water holding capacity in soils of ten sites was in the range of 47.1±3.2% - 58.4±2.7%. The soils of sites 1- 4 had low holding capacity (47.1± 3.2% to 49.3±2.0%). The sites 5-7 had water holding capacity from 52.2±3.1% to 55.2±3.8 % and the sites 8-10 had water holding capacity from 54.6±3.6 % to 58.4±2.7%

**Lead content in soil**: Heavy metal lead content in soil is given in table 3. Lead content was found higher at surface soil in comparison to soil at depth of 15 cm in all 10 sites. The surface soil average lead content ranged from 4.5± 0.7mg/kg at Jalalpur to 9.5±0.4 mg/kg at Panihar. Average lead content of soil at depth of 15 cm ranged from 3.1± 0.4 mg/kg at site 2 Jalalpur to 6.5± 0.5 mg/kg at site 10 Panihar.

Table 4 summarizes the average and range of lead content in soils, and national and international permissible limits of lead in soil. It is significant to note that common range of lead in soil is 2-200 mg/kg and average is 10 mg/kg. In this present study the average lead content in agricultural soils of Gwalior was from 3.1 mg/kg to 9.5 mg/kg.

**Table 3. Lead content in surface soil and at depth of 15cm in agricultural soils of Gwalior**

| Lead content (mg/kg) in soil | | | | | |
|---|---|---|---|---|---|
| Site no. | Name of site | Surface soil | | Soil at depth of 15 cm | |
| | | mean | Range | Mean | Range |
| 1 | Rairu | 5.4±0.6 | 6.0-4.6 | 3.8±0.6 | 4.3-2.9 |
| 2 | Jalalpur | 4.5±0.7 | 5.6-3.9 | 3.1±0.4 | 3.7-2.7 |
| 3 | Baretha | 5.2± 0.8 | 6.1-4.1 | 3.9±0.3 | 4.4-3.5 |
| 4 | Tilori Malanpur | 5.1±0.5 | 5.8-4.5 | 3.7±0.4 | 4.5-3.4 |
| 5 | Jorasi | 7.0±0.7 | 8.1-6.2 | 5.1±0.8 | 5.9-4.0 |
| 6 | Samudan | 6.5±0.6 | 7.4-6.0 | 4.9±0.6 | 5.6-4.2 |
| 7 | Dabra | 6.1±0.8 | 7.3-5.4 | 4.6±0.6 | 5.7-4.2 |
| 8 | Bela ki Babdi | 8.6±0.3 | 9.0-8.4 | 6.1±0.4 | 6.7-5.8 |
| 9 | Nayagaon | 9.0±0.7 | 9.5-8.1 | 6.2±0.2 | 6.6-6.0 |
| 10 | Panihar | 9.5±0.4 | 9.9-8.9 | 6.5±0.5 | 7.2-5.9 |

**Table 4. Average lead content in soil samples and its comparison with different standards**

| Metal | Selected average for soils[a] (mg/kg) | Common Range for soil[b] (mg/kg) | Critical soil concentration[c] (mg/kg) | Indian standards[d] (mg/Kg) | European Union standards (EU 2002)[e] (mg/kg) | Present study (mg/kg) |
|---|---|---|---|---|---|---|
| Pb | 10 | 2-200 | 100-400 | 250-500 | 300 | 3.1-9.5 |

**Source:** [a]Allaway 1968[22], [b] Lindsay 1979[11], [c]Alloway 1995[23], [d]Indian standards (Awasthi, 2000)[24], [e]European standards (EU 2002 )[25].

**Vertical distribution of lead in soils at Panihar site:** Lead metal concentration at different depths showed variation and data is presented in figure 2. The lead content at soil surface was 9.5 mg/kg, and lead content in soil at depth of 10, 20, 30 and 40 cm was 7.5 mg/kg, 5.8 mg/kg, 3.8 mg/kg and 3.0 mg/kg respectively (Fig.2).

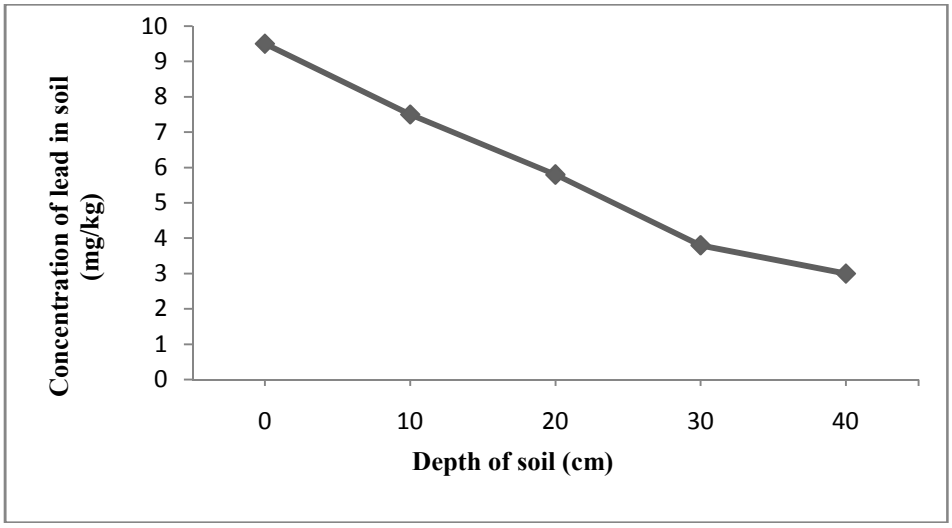


Figure 2. Lead concentration in soil profile.

**Lead metal concentration in soil at Panihar during Rabi crop season:** Two major crops grown in this area are Kharif crops during Monsoon and Rabi crops during winter (November to March). The lead content in soil at different time intervals during Rabi crop season (November 2016 to March 2017) at site 10 Panihar at farmer's field was studied .The lead content of surface soil was estimated at different time intervals from 1st November to 1st April. Fertilizers, manure were added to soil in the beginning of sowing of Rabi crop wheat in 1st week of November, 2016.The fluctuation in lead content in soil was observed in different months. The lead content in surface soil was 9.0 mg/kg and it increased to 9.5 mg/kg on 1st December, 2016,thereafter lead content in surface soil started decreasing, its concentration on 1st

January, 1st February, 1st March and 1st April 2017 was 9.3 mg/kg, 9.2 mg/kg, 9.1 mg/kg and 9.0 mg/ kg respectively (Figure 3).

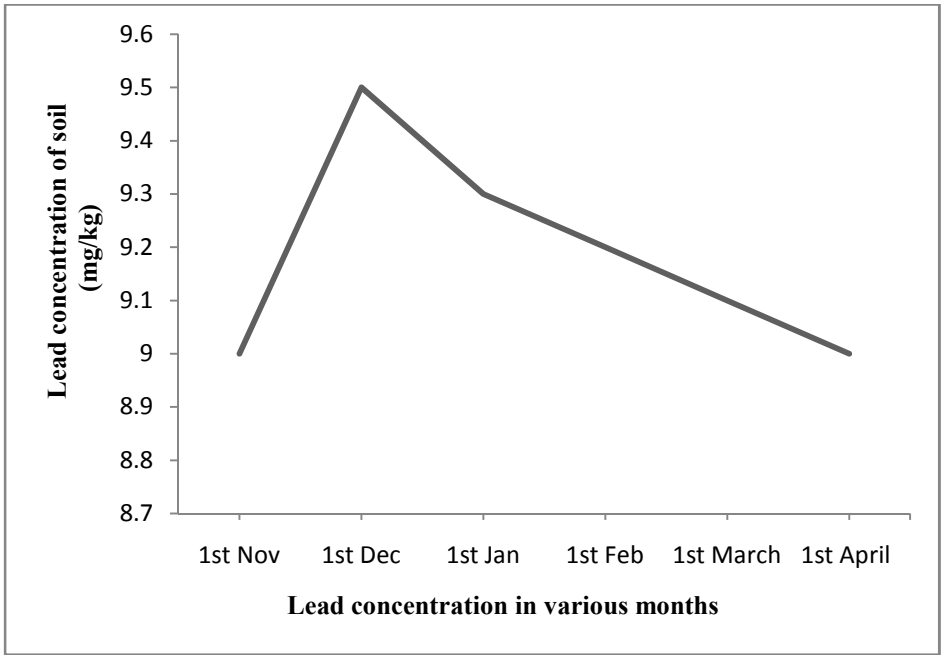


Figure 3- Fluctuation in lead concentration in surface soil at Panihar during winter season (November to March)

**DISCUSSION**

All soils were alkaline. Mobility of metals is effected by pH of soil.The mobility of lead is slow in alkaline soils [26] Electrical conductivity ranged from 0.35 mS/cm to 0.52 mS/cm., which indicated moderate level of the salinity. Variation in soil texture at various soils have been found, in sites 1- 4 soil was sandy loam and sites 5-10 soil was clay loam, which had more clay then sand. Heavy tillage implements led to deposition of clay in sub surface layer in intensive agriculture. Similar observations have beeen reported by other researchers [27, 28, 29]. It has been observed that sites 8-10 had more water holding capacity from 54.6%±3.6 to 58.4±2.7% and these three sites had also higher content of clay in soil, ranging from 44.8±3.9 % to 45.4± 27±2.7%. The water holding capacity was found related to texture of soil.

The lead content in soil varied in different sites. The lead content in surface soil was more than lead content in soil at 15cm depth in all sites. Soil is sink for heavy metals and accumulates at the top soil [6] and crop plants also take nutrients from this same zone [30] therefore lead may enter food chain through crop plants. Average lead content ranged from 4.5 mg/kg to 9.5 mg/kg in surface soil and 3.1 mg/kg to 6.5 mg/kg in soil at depth of 15cm. The least lead content was found at site No.2. Jalalpur at soil surface 4.5 mg/kg and at depth of 15 cm 3.1 mg/kg and maximum lead concentration at Panihar (9.5 mg/kg at surface and at depth of 15 cm 6.5 mg/kg.). The main sources of lead metal in soil samples were parent rock material, polluted irrigation water and various agrochemicals, fertilizers, manures, weedicides, fungicides used during cultivation. This study showed that three sites 8, 9, 10 Bela ki babdi, Nayagoan, Panihar had high content of lead in soil. Intensive agriculture practices including use of agrochemicals and manures is widespread in this area and the sites 8,9,10 are located adjacent to each other. Thus the high content of lead in soil in these three sites 8,9,10 may be partly due to soil characteristics of this area and partly due to intensive use of agrochemicals, fertilizers and manures. Site 1and site 4 are industrial areas and site 2 and site 3 are close to industrial areas, showed low content of Pb in soil, therefore, it seems that there was negligible influx of lead from industrial activity in this area.

Lead concentration in surface soil was high and lead concentration decreased with depth. The high concentration of lead at surface (0-20cm) showed the characteristics of enrichment at soil surface and relatively stable in deep soil layers. Similar results have been found by [31]. The pH is soil characteristics which effects the mobility of metals including lead in soil. Pb is slightly mobile in soil in pH range of 6.7-8.8 [26]. In this study pH of all sites was alkaline (7.12 to 7.41) and thus lead mobility was low.

The dynamics of lead in soil during Rabi season at site10 Panihar was studied and it was observed that the concentration of lead metal increased due to addition of fertilizers and manures in soil. The lead concentration was 9 mg/kg in soil before sowing of crop and addition of fertilizers and manure to soil in the beginning of sowing of crop increased lead content in soil and then slowly the lead content decreased over a period of 3 months. The lead metal in soil may have been leached vertically down wards and or uptaken by crops, weeds etc by process of bioaccumulation.

The results showed that lead concentration in soil was low in all sites, with reference to worldwide background content of lead range in soils. Although lead concentration in soil is low, but it does effect quality of agricultural products and pose health risk even at soil lead concentration of 3-9.5 mg/kg.

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