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Soil Nutrient Variation in Urban Forests of Gwalior with special reference to Available Potassium

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ABSTRACT
Urban forests play an important role in sustaining the environment of a particular area through different ways which are very efficient and cost effective among which vegetation is of prime importance that not only mediates the atmospheric gasses but also helps in cycling of nutrients. The study was taken to assess the role of nutrients and its variation due to various natural and edaphic factors. Standard methodology was adopted to assess the available potassium variation at different locations of Gwalior city of tropical India. The results revealed that the nutrient was found maximum at surface layer at all the sites during different seasons of the year with autumn showing maximum and summer minimum. The percentage change shows fluctuation for different sites and depths. The results concluded that cycling of nutrients like potassium can help in improvement of vegetation which directly or indirectly play a significant role in sustaining the urban area thus planting more and more trees will reduce the problem of carbon dioxide accumulation and increase the nutrient concentration.
Key words: *Available Potassium, Percentage change, Seasons, Urban forests*

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INTRODUCTION

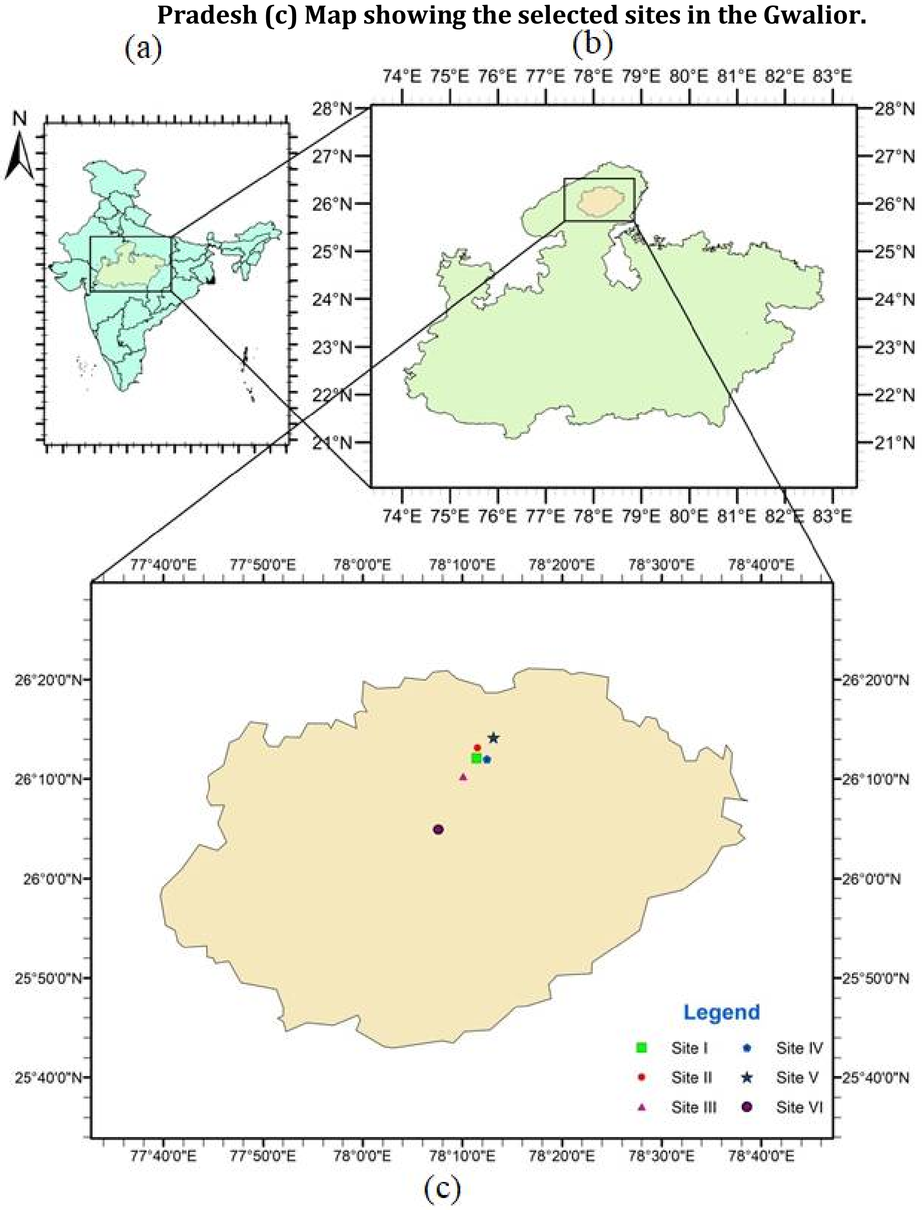
Urbanisation is a comprehensive phenomenon characterized by quickly shifting human populations and altering land cover [1]. The urban population of Asia is rapidly growing with almost 17 of the world's most densely populated cities and 12 of the world's most populated 25 cities such rapid growth is often not matched by increased services and facilities, resulting in the deterioration of urban environments [2]. Consequently, the expansion of urban construction will intensify as will the potential for emission of greenhouse gases [3] .GHGs and CO_2 are causing the environment and atmosphere to degrade significantly thereby causing climate change and global warming [4]. The urban and peri-urban areas are woodland systems which include forests, street trees, parks, gardens, institutions and abandoned areas [5] both artificial or natural vegetation patches covered by grass, shrubs, herbs, trees or any other type of plant [6]. Significant literature emphasises the role of urban forests in decreasing pollution and offsetting GHG emissions in cities [7, 8, 9,10]. Thus proper management and maintenance of urban forests are immensely required to maximize the health benefits of urban ecosystem [9]. Information in relevant concerns during different periods emphasizing the importance of urban forests to improve understanding of the link between urbanization and the environment is beneficial. In urbanized regions, trees have a multifaceted impact on the microclimate. As a result, it is vital to look into the biotic and abiotic elements that influence their health [11].Concentration of nutrients in soils determines the availability of various elements to plants and its presence in the soil can provide valuable information on nutrient and biochemical cycles in the soil-plant ecosystem [12]. For natural ecosystems, the relationship between soil and vegetation is crucial since soil formation is a continuous process therefore there is dynamic interrelationship between soil and vegetation. Physico-chemical properties of soil are strongly influenced by vegetation, increased infiltration, water-holding capability, hydraulic conductivity and soil aeration. Nutrients contribute to life support as well as with nitrogen, phosphorus, and potassium among the essential macro elements that restrict plant growth, yield and reproduction thus play a vital role in ecosystem functioning [13]. Potassium is usually the most abundant nutrient in soil [14] and supports the transportation of nutrients for growth e.g., nitrogen from the roots to the shoot and carbon from the source (shoot) to the sink (roots, storage organs like grains, tubers) [15, 16] It is usually flexible because it activates at least 60 enzymes involved in plant growth and development [17]. Potassium also acts as a constituent of enzymes and as a regulator of drought tolerance and water-use efficiency. The retention of K in soil and the accumulation of residues as reserves are very dependent on soil composition and physical environmental factors which influence the adsorption and release of K and its leaching through the soil profile [14]

MATERIAL AND METHODS

Study Area

The study area was central part of India with six sites viz. Jiwaji University Gwalior designated as Site I, Laxhmi bai National Institute of Physical Education as Site II, Tapovan Forest as Site III , Sharda Balgram Ashram as Site IV, Sun Temple as Site V and Sheetla Mata Mandir as Site VI. The area is tropical in nature with temperature reaching up to 47°C, experiencing heavy rainfall during monsoon with high humidity followed by cold winter. Base map of the research area was drawn by using Arc GIS [18] .The coordinate system is used in world Geodetic System (WGS), 1984. Fig 1(a) depicts the research area's location on an India's map, whereas Fig 1(b) depicts study area's location in Madhya Pradesh, India. The layout of Gwalior city shown in Fig 1(c). The longitudinal extent of the study area is considered from 74°E to 83°E and latitude extent is 21°N to 28°N for Madhya Pradesh (Fig.1 (b)). Similarly longitudinal extent for Gwalior city is considered from 77°40'0'' to 78°40'0''E and latitude extent from 25°40'0''N to 26°20'0''N (Fig.1 (c)).

FIG. 1 (a) Map depicting the study area within India. (b) Map depicting the study area in Madhya Pradesh (c) Map showing the selected sites in the Gwalior.



Experimental Layout

Four permanent quadrats of 20m × 20m were established at each site of the study area. All the quadrats were marked with paint and steel plates were fixed to the corner trees of the quadrat for identification and demarcation. The available potassium was evaluated using soil samples collected at depths of 0–10 cm, 11–20 cm and 21–30 cm from 2018 to 2020. Collected samples were taken to the laboratory for testing after proper labeling and marking.

Available potassium [19]

Soil samples of known weight were taken following air drying and pH adjustment to neutral with the addition of 0.1N ammonium acetate. After filtration, the extractant was tested with a flame photometer (Systronic's flame photometer 128).

RESULTS

Available Potassium

Available potassium (kg/ha) during summer season of year 2018-2019

During summer season of 2018, the results of available potassium revealed highest value recorded at Site II (327.00 kg/ha,215.67 kg/ha, 96.55 kg/ha for 10 cm, 20 cm and 30 cm) and lowest at Site VI (107.27 kg/ha , 105.22 kg/ha ,96.88 kg/ha for 10 cm, 20 cm and 30 cm) respectively similarly in 2019 Site II (337.00 kg/ha, 223.17 kg/ha, 102.17 kg/ha for 10 cm, 20 cm and 30 cm) showed highest and Site VI (112.48 kg/ha, 108.50 kg/ha and 97.72 kg/ha for 10 cm, 20 cm and 30 cm) recorded lowest value **(Table 1)**. All the sites revealed negative relation with increasing depth. The results were not found statistically significant at $P<0.05$ among different sites with P value 0.1633 and (R^2= 0.4224) following Newman-Keuls Multiple comparison test for ANOVA at P value 0.05. As far as Annual Percentage change is concerned during summer it was found highest at Site III (8.16 %) at 10 cm of soil depth, Site V (7.76 %) at 20 cm of soil depth and Site I (9.78 %) at 30 cm of soil depth. While lowest percentage change was found at Site I (3.00 %) at 10 cm, Site VI (3.11%) at 20 cm and (0.86 %) at 30 cm of soil depth at Site VI **(Fig 2)**.

Available potassium (kg/ha) during Monsoon season of year 2018-2019

Available potassium during monsoon of 2018 was observed highest at Site II (332.00 kg/ha) at 10 cm and (245kg/ha and 185kg/ha) at Site I similarly trend was observed during 2019 with highest at site II (349.97kg/ha) for 10 cm and Site I (248.33 kg/ha, 193.33 kg/ha) at 20 cm and 30 cm of depth respectively. Lowest results were found at Site VI with 115.57 kg/ha, 108.03 kg/ha, 99.67 kg/ha and 125.68 kg/ha, 114.47 kg/ha, 101.00 kg/ha at 10 cm 20 cm and 30 cm in 2018 and 2019 respectively **(Table 2)** At all the Sites highest results for available potassium were found at 10 cm followed by 20 cm and 30 cm with decrease in value along with depth. The results were found statistically significant at $P<0.05$ among different sites with P 0.0332 value and (R^2= 0.5273) following Newman-Keuls Multiple comparison test During monsoon Site VI observed highest percentage change 8.74 % at 10 cm of soil depth, Site V (6.14 %) at 20 cm and Site III (8.13 %) at 30 cm of soil depth. While lowest value was found at Site I (2.84 %) and (1.35 %) at 10 cm and 20 cm of soil depth .At 30 cm Site VI (1.33 %) recorded the lowest value **(**Fig. 3).

Table 1: Available potassium (kg/ha) during summer season year of 2018-2019

Depth (cm)	2018						2019					
	SITE I	SITE II	SITE III	SITE IV	SITE V	SITE VI	SITE I	SITE II	SITE III	SITE IV	SITE V	SITE VI
10	257.28 ±0.59	327.00 ±0.53	134.05 ±1.70	134.17 ±4.64	216.90 ±49.43	107.27 ±2.27	265.22 ±18.73	337.00 ±0.48	145.00 ±5.11	140.00 ±4.1	225.1 ±2.59	112.48 ±1.67
20	178.33 ±11.67	215.67 ±2.70	118.18 ±5.12	120.00 ±7.64	171.67 ±23.51	105.22 ±2.7	185±106.91	223.17 ±0.72	122.00 ±2.89	125.02 ±2.54	185.02 ±2.83	108.50 ±1.75
30	132.08 ±17.92	96.55 ±0.85	110.08 ±2.00	112.50 ±8.78	113.60 ±17.64	96.88 ±1.88	145.00 ±11.67	102.17 ±0.37	118.50 ±2.89	120 ±2.27	120.03 ±0.45	97.72 ±3.9

Table 2: Available potassium (kg/ha) during Monsoon season of year 2018-2019

Depth (cm)	2018						2019					
	SITE I	SITE II	SITE III	SITE IV	SITE V	SITE VI	SITE I	SITE II	SITE III	SITE IV	SITE V	SITE VI
10	293.65 ±8.18	332.00 ±3.47	158.33 ±1.31	160.43 ±3.27	290.87 ±3.15	115.57 ±2.78	302.42 ±10.97	349.97 ±0.32	169.17 ±1.79	173.02 ±1.52	310.83 ±4.34	125.68 ±2.00
20	245.00 ±2.89	229.00 ±2.69	134.6 ±2.05	152.70 ±1.78	228.67 ±1.68	108.03 ±1.39	248.33 ±11.67	238.35 ±1.73	140.27 ±3.12	160.42 ±2.53	243.33 ±0.85	114.47 ±2.76
30	185.00 ±7.64	111.05 ±3.07	119.67 ±2.44	140.58 ±2.4	156.92 ±1.62	99.67 ±1.01	193.33 ±20.48	116.1 ±2.78	129.40 ±2.26	143.18 ±1.82	161.47 ±1.61	101.00 ±1.84

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Table 3: Available potassium (kg/ha) during Winter season of year 2019-2020

Depth (cm)	2019						2020					
	SITE I	SITE II	SITE III	SITE IV	SITE V	SITE VI	SITE I	SITE II	SITE III	SITE IV	SITE V	SITE VI
10	333.33 ±6.67	356.77 ±0.73	167.25 ±1.96	169.38 ±2.26	327.8 ±3.03	122.2 ±3.42	341.67 ±4.41	360.15 ±1.27	172.48 ±3.74	173.33 ±7.26	331.23 ±6.14	128.82 ±2.04
20	290 ±5	242.35 ±1.26	152.53 ±1.83	154.13 ±1.53	260.08 ±2.59	114.50 ±1.78	298.33 ±9.28	248.4 ±2.07	157.22 ±1.74	162.75 ±5.44	270.85 ±3.85	120.62 ±2.93
30	223.33 ±13.02	129.42 ±6.29	140.22 ±3.08	141.62 ±4.22	218.3 ±46.22	104.20 ±1.15	240 ±20	135 ±2.89	148.37 ±1.71	149.95 ±0.97	223.33 ±18.56	108.83 ±1.96

Fig 2: Annual percentage change in Available Potassium during summer 2018-2019

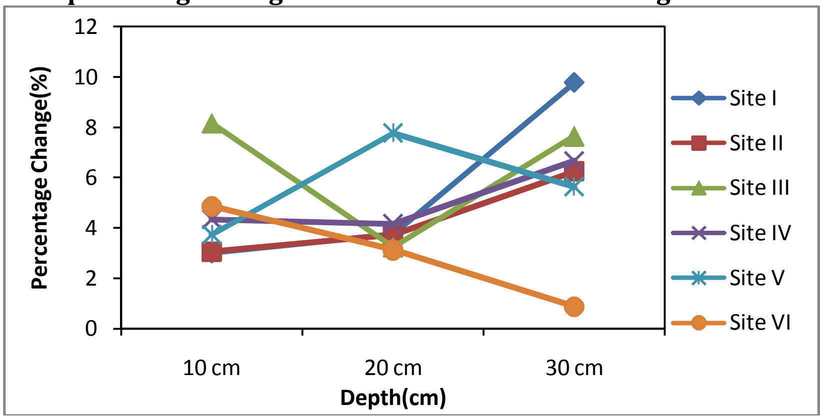


Fig 3: Annual percentage change in available Potassium during Monsoon 2018-2019

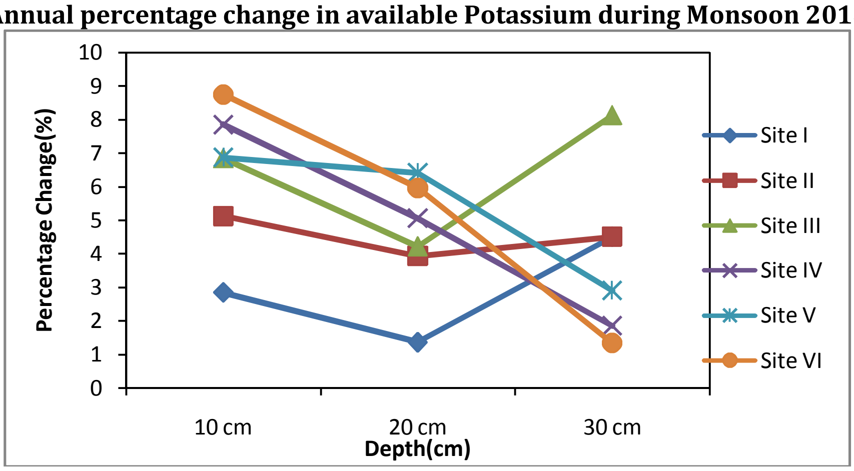
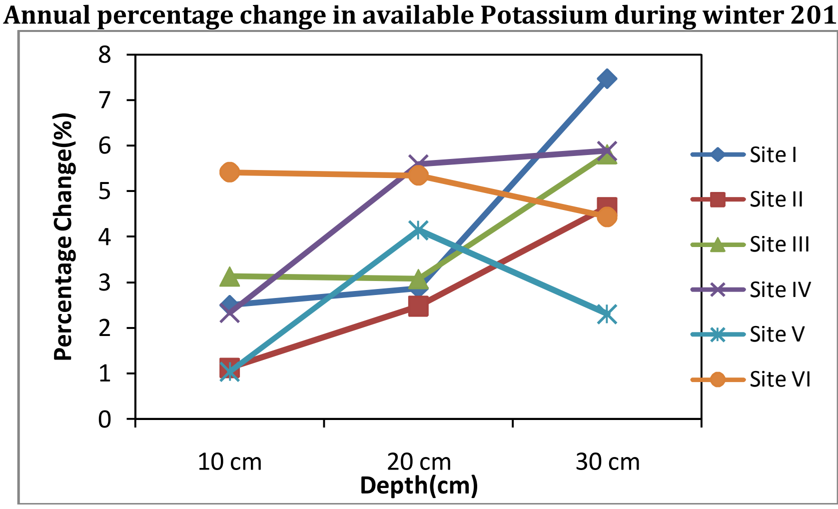


Fig 4: Annual percentage change in available Potassium during winter 2019-2020



Available potassium (kg/ha) during winter season of year 2019-2020

During winter season of 2019 and 2020, highest value for available potassium was observed at Site II (356.77 kg/ha) for 10 cm, Site I (290.00 kg/ha and 223.33 kg/ha) at 20 cm and 30 cm of depth respectively in 2019. Site II again recorded highest results for 10 cm of depth (360.15 kg/ha), Site I (298.33 kg/ha and 240 kg/ha) 20 cm and 30 cm respectively similarly Lowest valve for available potassium of 2019 and 2020 was observed at Site VI (122.20 kg/ha, 114.50 kg/ha, 104.20 kg/ha and 128.82 kg/ha, 120.62 kg/ha, 108.83 kg/ha) for 10 cm 20 cm and 30 cm respectively. With increases in depth there was decrease in available potassium (Table 3). The results were found maximum at top layer than sub surface layers. The results were found statistically significant at $P<0.05$ among different sites with P value (0.0012) and (R^2= 0.6667) following Newman-Keuls Multiple comparison test. During winter highest percentage was found at Site VI (5.41 %) Site IV (5.59 %) and Site I (7.46 %) for 10 cm, 20 cm and 30 cm of soil depth respectively. Lowest value for percentage change was observed at Site V (1.04 %) Site II (2.47 %) and Site V (2.30 %) for 10 cm, 20 cm and 30 cm of soil depth (Fig 4).

DISCUSSION

Available potassium was evaluated during different seasons and depths at all the sites. The results of available potassium revealed that all the fractions showed highest values during winter season followed by monsoon and summer. The work on seasonal changes of the nutrients in the soil under different land was also done by [20] and showed that under natural forest available potassium during winter season was highest and summer lowest respectively which is in accordance with the current study. From the above study it was concluded that more the organic matter more is the accumulation of minerals in the soil as reported by [21] which shows positive correlation between organic matter and available potassium. Depending on the kind of clay minerals present, potassium values often increase throughout the winter months due to alterations in soil equilibrium conditions caused by freezing and thawing operations releasing fixed potassium from non-exchangeable forms [22 ,23]. Seasonal variation on nutrients was also done by [24 ,25 26 27] and they reported that litter fall varies with the season, which has a direct impact on SOC and nutrient levels.

Available potassium was high at Site I and Site II than other Sites almost in all the seasons and at all the depths. The reasons for the same may be due to the high girth class of trees which leads to more litter content as the litter fall has great impact on nutrient concentration [27]. Besides Site I and Site II are protected and intensively managed area where all litter fall gets converted into nutrient through the process of decomposition and this may be the reason of varying potassium between the sites. [28] studied positive effects of afforestation efforts on the health of urban soils and suggested that urban afforestation and preparation of urban soils for tree planting improves the health of urban soils by improving soil properties and consequently the urban environment.

Available potassium variation was observed at different depths with higher value at surface layer of soil than sub surface layer which is supported by [29] who also concluded that available potassium was medium in surface layers and showed a regular decrease with the depth while studying available soil nutrients at Langate area of Kupwara region of Kashmir. [30] studied the forms and distribution of potassium in Kavalur sub-watershed soils of Koppal district, Karnataka and concluded that the surface available potassium in soils was more compared to sub-surface. [31] determine depth-wise soil parameters distribution in the apple growing areas of Gharpajhog Rural Municipality, Nepal and their study concluded that surface depth possessed strong content of studied soil parameters including potassium .

The relative effects of factors such as soil texture, intensity of weathering of surface soils, organic carbon content and release of soluble potassium from organic residues, application of potassic fertilisers and leaching of potassium to lower horizons may be the cause of variation in available and total potassium distribution in the depth wise season wise or site wise. Some studies have observed that soil potassium is mainly accumulated in soil through the action of decomposition and mineralization of soil organic matter [32,33] . They further concluded that soil enzymes are primarily adsorbed on organic matter particles in the soil or mixed with humus, impacting soil characteristics, nutrient cycling, and potassium and nitrogen release. It could be because dense vegetation which provides appropriate cover for the soil, decreasing the loss of soil micro and macro nutrients that are important for plant growth and energy fluxes, as grassland has less vegetation cover .It was observed from the above results that more the organic matter, more is the accumulation of minerals in the soil.

CONCLUSION

The study concludes that the available potassium varies both season as well as on annual basis. The depth revealed negative trend with increasing depth at both the sites but the vegetation helps in cycling as well as formation of nutrients constantly as estimated. Nutrients like available potassium helps in regulating and maintaining the urban ecosystem efficiently by making healthy flora which directly consumes these gasses and helps in sequestration of the area. The Gwalior is industrialized city with different green patches located at random places and these patches play a vital role in conservation of the area. The main focus should be on afforestation in the area which further enhances the nutrient quantity as well as vegetation for sequestering the atmospheric gases. Future research should examine urban soil properties in various spatial and temporal scales. This would provide more specific information about the spatial and temporal variability in urban soils to develop appropriate techniques and strategies for future urban design and planning.

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CONFLICT OF INTEREST

There is no conflict of interest

AUTHOR'S CONTRIBUTION

All the authors contributed equally at their respective stages.

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