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Chemical Assessment of Soil Quality of Madhepura District (Bihar): A Review

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Abstract : This review summarises existing knowledge of soil chemical properties in regions geographically and geologically proximate to Madhepura District in Bihar, India. In the fertile Indo-Gangetic Plain, Madhepura shares common soil characteristics with neighboring districts such as Purnea, Samastipur, Muzaffarpur, and Katihar. Studies indicate that these soils are predominantly sandy loam to loam, mildly acidic to slightly alkaline, with low to medium organic carbon and macronutrient levels, particularly nitrogen (N), phosphorus (P), and potassium (K). Given this, it is plausible that soils in Madhepura exhibit similar deficiencies, affecting fertility and crop productivity. This review collates physico-chemical analyses from neighbouring districts, extrapolates potential soil chemistry trends for Madhepura, and outlines strategies for improved soil management tailored to the region. The data collected in this review paper will be used as secondary data, which will be helpful to complete my research work and is also related to the soil quality of Madhepura District, Bihar.

(Keywords : Soil chemical properties, Indo-Gangetic Plain Soil characteristics, Macronutrient levels).

Introduction

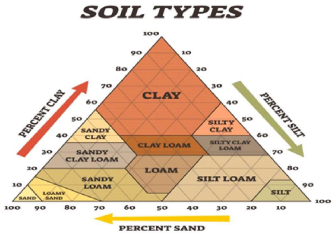
Soil quality is the fundamental determinant of agricultural productivity, particularly in the agrarian economy of Bihar[1]. The Madhepura district, situated in the Kosi region of the Indo-Gangetic Plain, relies heavily on crop production[2]. However, site-specific soil data for Madhepura is often less accessible compared to its prominent neighbors like Purnea and Muzaffarpur[3,4].

Understanding the chemical profile—specifically pH, organic carbon (OC), and macronutrients (N, P, K)—is critical for developing effective fertilizer schedules[5,6]. This paper reviews the physico-chemical properties of soils in districts surrounding Madhepura to construct a predictive profile of Madhepura's soil health, aiming to guide future research and agricultural interventions.

Geographical and Geological Context

Madhepura is located in the flood plains of the Kosi River. Geologically, the soil is Quaternary alluvium, deposited by the oscillating courses of the Kosi and its tributaries[7,8].

- **Soil Texture:** The riverine origin dictates the texture. As the Kosi flows with high velocity carrying heavy silt loads, the deposited soil is predominantly Sandy Loam to Loam[9].
- **Alluvial Nature:** These soils are young (Entisols and Inceptisols), characterized by stratification and varying depth, often lacking distinct horizon development due to recurrent deposition[10,11].



Physico-chemical Analysis of Neighbouring Districts

To infer the soil quality of Madhepura, we analyze data from four geographically proximate districts that share the same agro-climatic zone (Zone II and Zone I of Bihar).

Purnea District (East of Madhepura)

pH & EC: Soils in Purnea are reported to be slightly acidic to neutral (pH 6.5 – 6.8)[3]. This acidity is often attributed to the leaching of bases due to higher rainfall and organic matter decomposition. Electrical Conductivity (EC) is generally normal (< 1 dS/m)[12].

Macronutrients:

Nitrogen (N): Low available Nitrogen (~208 kg/ha)[3].

Phosphorus (P): Low to Medium (~14.5 kg/ha)[12,13].

Potassium (K): Low (~123 kg/ha)[14].

Organic Carbon: Generally low, averaging around 0.24%, indicating poor water holding capacity and nutrient retention[3].

Samastipur District (West/South-West)

pH: In contrast to Purnea, soils here tend to be slightly alkaline (pH 7.4 – 8.0), likely due to calcareous deposits (calcium carbonate) common in the western Indo-Gangetic plains[15,16].

Nutrient Status:

Nitrogen: Low to Medium (168–260 kg/ha)[17].

Phosphorus: Low (24.8–37.8 kg/ha)[16].

Potassium: Medium (134–205 kg/ha)[18].

Organic Carbon: Ranges from 0.35% to 0.54%, which is low but slightly better than Purnea[15].

Muzaffarpur District (West)

pH: Predominantly neutral to alkaline (pH 7.10 – 8.50)[4]. High pH in some pockets affects the availability of micronutrients like Zinc.

Nutrient Status:

Nitrogen: Deficient (~178 kg/ha)[19].

Phosphorus: Low to Medium (~13 kg/ha)[4].

Potassium: Medium (~140 kg/ha)[4].

Micronutrients: Zinc (Zn) deficiency is a widespread issue reported in these calcareous soils[20].

Katihar District (South-East)

Texture: Predominantly Sandy Loam, similar to Madhepura[21].

Chemical Properties: The soil reaction is mildly acidic to neutral. Organic carbon is critically low (~0.33%), leading to poor physical structure and nutrient leaching[22].

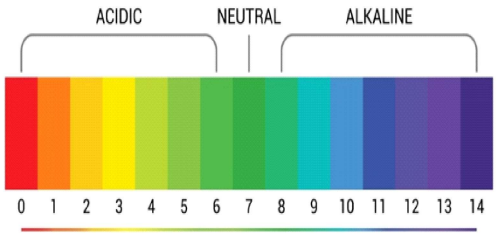
Extrapolated Trends for Madhepura District

Based on the data from neighboring districts and the shared geological origin (Kosi alluvial fan), the following chemical trends can be extrapolated for Madhepura[8,23]:

Parameter	Extrapolated Trend for Madhepura	Rationale (Based on Neighbors)
Soil Texture	Sandy Loam	Influence of Kosi river deposits (similar to Purnea/ Katihar)[7,21].
Soil pH	6.5 – 7.5 (Neutral)	Transition zone between acidic soils of Purnea and alkaline soils of Samastipur[24,3,15].
Organic Carbon	Low (< 0.5%)	High oxidation rate due to temperature and intensive tillage; sandy texture promotes rapid decomposition[25].
Nitrogen (N)	Deficient (Low)	Consistent trend across the entire Indo-Gangetic Plain due to low organic matter[26,27].
Phosphorus (P)	Low to Medium	Likely fixation in calcium-rich pockets or leaching in sandy acidic pockets[28].
Potassium (K)	Medium	Alluvial soils generally have adequate K-bearing minerals (mica), but intensive cropping is depleting reserves[10].
Micronutrients	Zn Deficiency	Likely widespread, especially in areas with higher pH[29].

Validation from Local Studies:

Limited specific studies on Madhepura[24] validate these extrapolations, reporting pH values oscillating between 6.5 and 7.4 and consistently low Nitrogen levels. However, localized variations exist; for instance, parts of the BihariGanj block in Madhepura have shown unexpectedly High Phosphorus levels in recent surveys, likely due to excessive DAP (Di-ammonium Phosphate) application by farmers, contrasting with the regional deficiency trend[30].



Interpretation of Table 1

As presented in Table 1, a comparative analysis reveals a distinct chemical gradient across the region. While districts to the west like Samastipurand Muzaffarpur exhibit alkaline tendencies (pH > 7.5) due to calcareous alluvium[4,15], Purnea to the east leans towards acidity (pH < 6.8)[3]. Madhepura, situated geographically between these zones, effectively acts as a transition belt, likely maintaining a neutral pH (6.5–7.4)[9,24].

However, a unifying constraint across all five districts is the critical deficiency in Nitrogen (< 250 kg/ha) and Organic Carbon (< 0.5%)[26], necessitating a uniform strategy for organic amendment application. Unlike Purnea, where Potassium is low, Madhepura's soil appears to retain medium levels of Potassium, likely derived from the mica-rich Kosi silt, similar to trends observed in parts of Katihar[22].

Table -1
Comparative Status of Soil Physico-chemical Properties

District	Soil Reaction (pH)	Organic Carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)	Soil Texture Class
Purnea[3,12]	6.52 – 6.82 (Slightly Acidic)	0.24 (Very Low)	208.8 (Low)	14.5 (Low-Medium)	123.5 (Low)	Sandy Loam
Samastipur[15,16]	7.50 – 8.30 (Alkaline)	0.50 (Low-Medium)	218.3 (Low)	20 – 35 (Medium)	136 – 237 (Medium)	Sandy Clay Loam
Muzaffarpur[4,19]	7.10 – 8.50 (Neutral to Alkaline)	0.47 (Low)	178.5 (Low)	12.9 (Low-Medium)	139.7 (Medium)	Loam to Sandy Loam
Katihar[21,22]	6.8 – 7.8 (Neutral to Alkaline)	0.33 (Low)	Low - Medium	Low - Medium	Low - Medium	Sandy Loam
Madhepura*[24,30]	6.5 – 7.4 (Neutral)	< 0.50 (Low)	Deficient (< 250)	Satisfactory (Medium)	Satisfactory (Medium)	Sandy Loam

Management Strategies

To address the identified deficiencies in Madhepura, the following management strategies are recommended:

Amelioration of Organic Carbon:

Incorporation of crop residues rather than burning[27].

Mandatory inclusion of Green Manuring (e.g., *Dhaincha* or *Sunhemp*) in the crop rotation every 2-3 years to boost Organic Carbon and Nitrogen[31].

Nitrogen Management:

Since N is universally low[6], split application of Urea is necessary to reduce leaching losses in sandy loam soils.

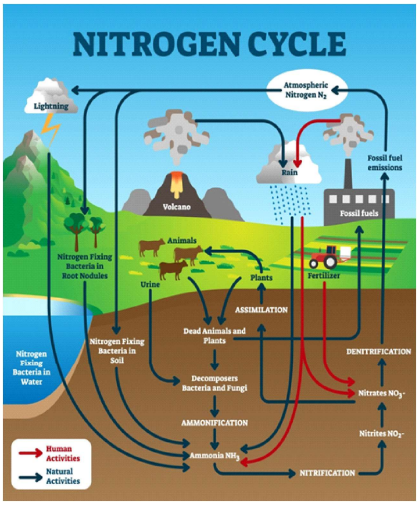
Use of Neem coated Urea to slow down nitrification

Micronutrient Fortification:

Soil application of Zinc Sulphate (25 kg/ha) is critical for paddy and maize crops, which are sensitive to the Zinc deficiency common in this belt[29].

Site-Specific Nutrient Management (SSNM):

Moving away from blanket fertilizer recommendations to Soil Health Card-based application[9], specifically monitoring the rising P levels in certain blocks to prevent toxicity and groundwater pollution[30,32].



Conclusion

The soil of Madhepura District, being an integral part of the Indo-Gangetic alluvium, mirrors the chemical properties of its neighbors[23]. It is characterized by a light texture (sandy loam), neutral pH, and a general deficiency in Organic Carbon and Nitrogen. While Phosphorus and Potassium levels may vary locally due to fertilizer practices, the overarching need is for integrated nutrient management[28]. Increasing the organic matter content is the single most critical intervention required to sustain soil fertility in Madhepura.

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