

Assessment of Physico-Chemical Properties of Soil and Irrigation Water Quality of Phulpur Block of Prayagraj District, Uttar Pradesh

ABSTRACT

The study of nutrient status in phulpur block of Prayagraj District of Uttar Pradesh. Representative soil samples were collected covering nine villages of phulpur division before sowing of crop. The soil samples were analyzed for their Physico-chemical Properties. These samples were taken from different villages of phulpur blocks and depths like 0-15cm, 15-30cm and 30-45cm. Results show that the soil samples of the areas of phulpur division were found to be mildly alkaline and non-saline. There are many reasons leading to soil quality deterioration, including changes in land use types from forest to arable land and the consequences from intensive land use. The colour of soil changes between the three depths at all the locations. There was also a difference in colour of dry and wet soils was dark brown to dark yellowish brown. Results show that soil Bulk density varied from 1.31 to 1.48 Mgm^{-3} , soil Particle density varied from 2.44 to 2.57 Mgm^{-3} , Percent of Pore space from 43.09 to 48.21%, Water Holding Capacity from 35.73 to 44.24% respectively. Soil pH varied from 7.75 to 8.92 and EC is 0.18 to 0.37% respectively while soil Organic Carbon varied from 0.28 to 0.55% and Available Nitrogen varied from low to medium i.e., 216 to 323 kg ha^{-1} Available Phosphorus varied from medium to high range i.e., 14.05 to 25.71 kg ha^{-1} and Potassium was found to be medium range i.e., 137.00 to 236.00 kg ha^{-1} , Exchangeable Calcium and Magnesium low from 3.34 to 5.66 $\text{Meq } 100\text{g}^{-1}$ and 1.36 to 2.74 $\text{Meq } 100\text{g}^{-1}$. The pH of water varied from 6.24 to 7.50. The Electrical Conductivity of water ranged from 0.31 to 0.90 dS m^{-1} . The Bicarbonate of water varied from 7 to 18 Meq L^{-1} . The chloride of water varied from 4.5 to 10.4 Meq L^{-1} . The Available calcium of water varied from 4.2 to 8 kg ha^{-1} . The Available Magnesium of water varied from 2.5 to 3.6 kg ha^{-1} . The Potassium of water varied from 0.05 to 0.17 Meq L^{-1} . The Sodium of water varied from 0.08 to 0.21 Meq L^{-1} respectively. The Sodium Absorption Ratio (SAR) values ranged from 0.03 to 0.1 Meq L^{-1} , indicating low to moderate levels of sodium content in the water samples. The soluble sodium percent (SSP) values ranged from 1.47 to 3.93 Meq L^{-1} , providing further insight into the sodium content in the water. The residual sodium carbonate (RSC) values varied from -2.4 to 7.4 Meq L^{-1} . The Permeability Index (PI) values ranged from 28 to 56 Meq L^{-1} , serving as an indicator of the

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potential impact of water on soil permeability. Lastly, the Kelley's ratio (KR) values ranged from 0.08 to 0.024 Meq L⁻¹. The KR is a measure of the sodium hazard in irrigation water, with lower values indicating a lower risk of sodium-related issues in soil and crops. The range of the irrigation water quality index value ranged from 44 to 157 Meq L⁻¹; it was determined that 100% of the samples are in good range for irrigation.

Keywords: *Physico-chemical, Properties, Organic Carbon, pH, Nitrogen, Phosphorus, Soil, Potassium, Analysis.*

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Introduction

Soil and water are two important natural resources for plant growth development. Soil provides the mechanical support and nutrient reservoir necessary for plant growth. Water is essential for plant life processes. Effective management of these resources for crop production requires to produce to understand relationships between soil and water.

Soil, an unconsolidated material from the Earth's crust, serves as a natural medium for plant growth, dependent on factors like adequate water, temperature, nutrients, and low toxic concentrations. It comprises 50% pore space (air and water) and 50% solid phase, with 45% mineral matter and 5% organic constituents. (Soils and Plant Nutrients).

Distinguished as a natural body, soil consists of layers, known as soil horizons, which encompass weathered mineral materials, organic matter, air, and water. The formation of soil is a complex result of the combined influences of climate, topography, organisms (flora, fauna, and human activities), and parent materials (original rocks and minerals) over time. Consequently, soil exhibits unique properties, different from its parent material, including variations in texture, structure, consistency, color, chemical, biological, and physical characteristics.

Recognized as an essential component of both "Land" and "Eco-systems," soil plays a crucial role in broader concepts encompassing vegetation, water, and climate within the realm of land. Moreover, in the case of ecosystems, social and economic considerations come into play as well (FAO). The significance of soil as a non-renewable dynamic resource cannot be overlooked, as it constitutes unconsolidated minerals and organic matter, including water and air, within the uppermost layers of the Earth's surface. It plays a critical role in maintaining terrestrial ecosystems, which support all life (Andrew *et al.*, 2020).

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The physical and chemical properties of soil hold immense importance in facilitating a plant's ability to extract water and nutrients. The product of biochemical weathering of parent material, soil formation is influenced by factors such as climate, organisms, parent material, relief, and time (Belwal and ~~mehta~~-Mehta 2014). High-quality soils not only yield better food and fiber but also foster the establishment of natural ecosystems and enhance air and water quality. Physical properties, such as shape, structure, size, pore space, organic matter, and mineral composition, directly impact the supporting capability, movement, retention, and availability of water and nutrients to plants. Additionally, they influence root penetration, heat and air flow, and interact with chemical and biological properties of the soil. Soil and water constitute fundamental resources for plant growth and agriculture. However, despite Earth's extensive water coverage, only a minute fraction is available for human consumption due to environmental stress caused by developmental activities.

Irrigation water quality significantly impacts soil quality and crop growth. With only 1% freshwater available, its quality, influenced by sediment and salt quantities from various sources, affects osmotic potential, hindering root water absorption. The quality of irrigation water significantly impacts crop yield and soil characteristics, influenced by diverse factors like climate, environment, and soil composition Alper *et al.*, (2016). Analysis of water quality involves assessing physical, chemical, and biological properties (Chapman, 1996), critical for plant health and environmental preservation. Irrigating crops with sewage water containing heavy metals poses severe health risks to consumers and farmers. The suitability of irrigation water depends on dissolved constituents, with lower divalent ions deemed better. Urbanization and industrialization exert pressure on water resources, especially groundwater, leading to compromised quality and health hazards. India's heavy reliance on groundwater for drinking necessitates thorough quality assessment. Extensive research on the Water-water Quality quality Index-index (WQI) aids in evaluating and managing groundwater resources, essential for sustainable usage amid increasing pollution concerns (Meireles *et al.*, 2010).

In this context, the study of the physico-chemical properties of soil and water collected from various locations of Phulpur block of Prayagraj assumes paramount significance. Understanding and optimizing these properties are crucial for sustainable agricultural practices, ecosystem health, and the preservation of this invaluable resource.

1- Materials and Methods

1.1 Location:

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The location of phulpuris located on the map with the GPS coordinates of 25°55'10"N and 82°08'84" E.

1.2 Soil and Climate:

In Phulpur block of Prayagraj District, the climate is moderate both in winter and summer seasons in delta area. The normal maximum and minimum temperatures recorded in the district are 36.20°C to 19.0°C respectively. The annual rainfall is between 1045 and 1170 mm in northern Uttar Pradesh. Districts of the southern region of the Uttar Pradesh state receive less rain during the southwest monsoon. Uttar Pradesh contains various soil types, some of which are red soil, Alluvial soil, Black soil, Saline soil, Sandy coastal soil, Rocky hill soil, red soil is the most abundant among these soils. These soil types allow the planting of a variety of fruits and vegetable crops such as mangoes, Lemon, coconut, sugarcane, paddy, Maize and Chilies.

1.3 Sampling and Analysis

The soil sample collection is from Phulpur block of Prayagraj district in the state of Uttar Pradesh selecting 9 villages. Samples were collected randomly from a site of each village using soil khurpib y composite sampling method at a depth of 0-15cm, 15-30cm and 30-45cm. After sampling the samples were air dried in shade and then these samples were processed for various physical and chemical tests. The data was recorded during the course of investigation were subjected to statistical analysis by analysis of ~~Completely-completely~~ Randomized randomized Design—design (CRD) as per the method of "Analysis of Variance" (ANOVA) technique.

2.4 METHOD OF WATER SAMPLING AND PRESERVATION

First, in this study sample collection of Irrigation water was done in a ~~Sterilized~~ sterilized bottle. Nine water samples were collected from nine different villages in Phulpur block of Prayagraj district and ~~analysed~~ analyzed in Department of Soil Science and Agricultural chemistry, Sam Higginbottom University of Agriculture, Technology & Sciences, Uttar Pradesh. 2-3 drops of nitric acid ~~was~~ were also added in the samples to stop the growth of microbes.

Table 1: Procedure used for Physico-chemical analysis of soil and water

A. Physical analysis

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S.No.	Parameters	Scientist
1	SoilTextural Class(Sand,Silt,Clay)	Bouyoucos,(1927)
2	Bulk Density (Mg m ⁻³)	Muthuvel <i>etal.</i> ,(1992)
3	ParticleDensity(Mgm ⁻³)	
4	PoreSpace(%)	
5	WaterHoldingCapacity(%)	

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B. Chemical analysis

S.No.	Parameters	Scientist
1	Soil pH	Jackson,(1958)
2	Electrical Conductivity(dS m^{-1})	Wilcox,(1950)
3	Organic Carbon(%)	Walkley and Black,(1947)
4	Available Nitrogen(kg ha^{-1})	Subbiah and Asija,(1956)
5	Available Phosphorus (kg ha^{-1})	Olsen <i>et al.</i> ,(1954)
6	Available Potassium(kg ha^{-1})	Toth and Prince,(1949)
7	Exchangeable Ca and Mg ($\text{Meq } 100\text{g}^{-1}$)	Jackson,(1973)

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C. Chemical analysis

S. No.	Particulars	Scientist
1	pH	APHA (1992)
2	EC (dS m^{-1})	APHA (1992)
3	Carbonate and Bicarbonate (Meq L^{-1})	APHA (1992)
4	Chloride (Meq L^{-1})	APHA (1992)
5	Calcium + Magnesium (Meq L^{-1})	APHA (1992)
6	Calcium (Meq L^{-1})	APHA (1992)
7	Potassium (Meq L^{-1})	APHA (1992)
8	Sodium (Meq L^{-1})	APHA (1992)

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2. Result and Discussion

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2.1 Physical properties of Soil

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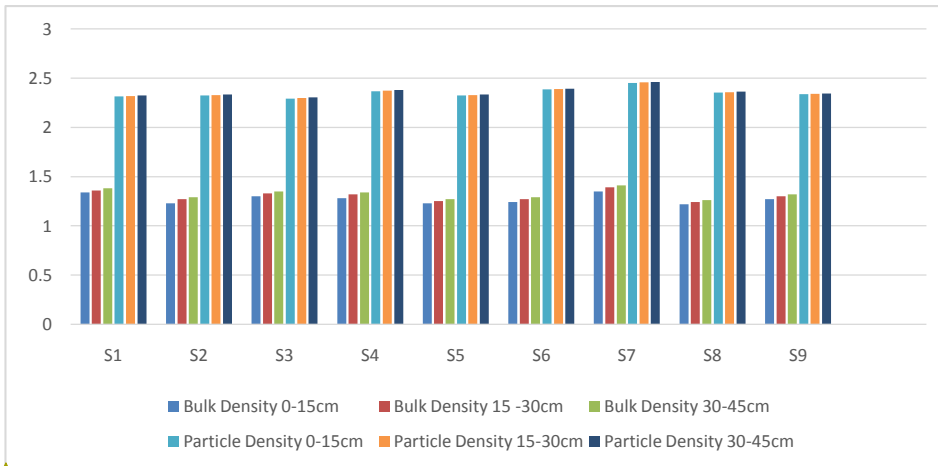
The ~~Soil~~ ~~soil~~ ~~Textural~~ ~~textural~~ class was identified as Sandy Loam. The sand, silt and clay percentage varied from 75.12 to 71.46% sand, 18.36 to 14.45% silt and 11.08 to 9.18% clay in Sandy Loam. Bulk Density was varied from the 1.22 to 1.41 Mg m^{-3} . Bulk density was found to increase with the increase in soil depth in some sites due to increase in compaction in the subsurface comparatively. The ~~Partic~~ ~~particle~~ ~~Density~~ ~~density~~ varied from 2.291 to 2.452 Mg m^{-3} . The increase in the particle density is due to soil depth, water quality, and their interaction.

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The ~~Pore~~ ~~pore~~ ~~Space~~ ~~space~~ (%) ranged from 41.60 to 48.20%. The pore space was found

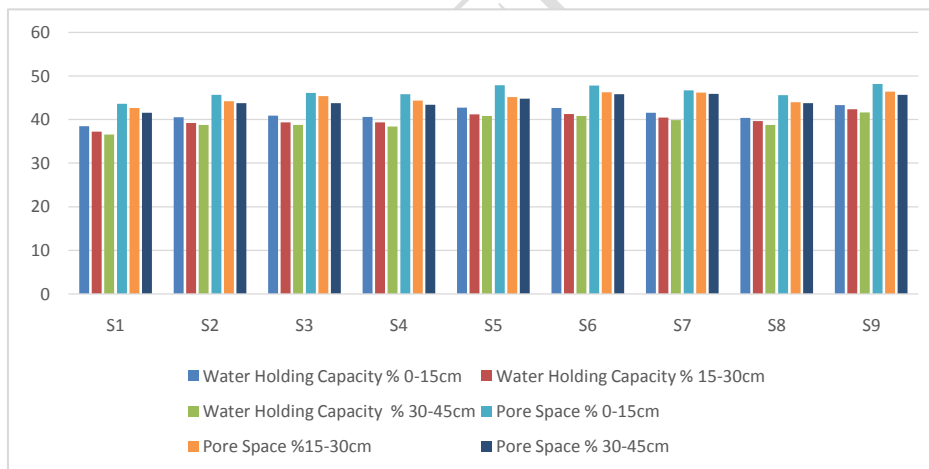
Depth (30-45cm)	S	0.671345	1.992669	S	0.591988	1.758888
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Fig.1: Bulk density, Particle density of soil in different villages of Phulpur block of Prayagraj district at 0-15cm, 15-30cm and 30-45cm depth.

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Fig.2: Pore space and Water holding capacity of soil in different villages of Phulpur block of Prayagraj district at 0-15cm, 15-30cm and 30-45cm depth.

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3.2 Chemical properties of Soil

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The pH value ranged from 7.26 to 7.84. The Electrical Conductivity range d from

0.24 to 0.38 dSm⁻¹ and the soil were found to be normal. The value of total Organic Carbon (%) varied from 0.29 to 0.45%. The organic carbon content decreased with increased depth, and this is due to the addition of plant residues and farmyard manure to surface horizons than lower horizons. The available Nitrogen content of soil ranged from 180.00 to 275.00 kg ha⁻¹ and nitrogen content was low in all blocks. The available Phosphorus content of soil ranged from 10.80 to 22.50 kg ha⁻¹. All the sites have low to medium phosphorus content. Available Potassium content of soil ranged from 132.0 to 231.0 kg ha⁻¹. All the sites have low to medium potassium content. Exchangeable Calcium content of soil ranged from 3.48 to 5.50 Meq 100g⁻¹. Exchangeable Magnesium content of soil ranged from 1.66 to 2.72 Meq 100g⁻¹. Calcium and Magnesium are low in the soil. Calcium and magnesium both increase as the soil pH increases in soil.

Table 4: Soil pH and EC (dSm⁻¹) of soil in different villages of Phulpur block of Prayagraj district at 0-15cm, 15-30cm and 30-45 cm depth

Villages	Soil pH			Soil EC (dS m ⁻¹)		
	0-15cm	15-30cm	30-45cm	0-15cm	15-30cm	30-45cm
V1	7.80	7.82	7.83	0.38	0.33	0.30
V2	7.26	7.29	7.31	0.35	0.33	0.30
V3	7.30	7.32	7.33	0.32	0.29	0.26
V4	7.67	7.69	7.72	0.35	0.30	0.25
V5	7.23	7.31	7.30	0.30	0.25	0.23
V6	7.78	7.81	7.81	0.33	0.30	0.28
V7	7.76	7.78	7.79	0.34	0.30	0.26
V8	7.79	7.79	7.80	0.35	0.32	0.29
V9	7.80	7.81	7.84	0.31	0.28	0.24
	F-test	S.Em. (±)	C.D@5%	F-test	S.Em.(±)	C.D@5%
Depth (0-15cm)	S	0.097750	0.097750	S	0.003846	0.011426
Depth (15-30cm)	S	0.080484	0.239130	S	0.004817	0.014313
Depth (30-45cm)	S	0.078097	0.232039	S	0.003031	0.009004

Table 5: Soil OC and Available Nitrogen of soil in different villages of Phulpur block of Prayagraj district at 0-15cm, 15-30cm and 30-45cm depth

Villages	Organic Carbon (%)			Nitrogen (kg ha ⁻¹)		
	0-15cm	15-30cm	30-45cm	0-15cm	15-30cm	30-45cm
V1	0.45	0.43	0.41	275	253	238
V2	0.40	0.39	0.38	270	253	237
V3	0.37	0.36	0.34	264	238	217
V4	0.35	0.34	0.33	227	197	180

V5	0.34	0.33	0.31	224	204	187
V6	0.32	0.30	0.29	218	198	180
V7	0.42	0.40	0.38	255	231	207
V8	0.38	0.37	0.36	244	224	206
V9	0.39	0.37	0.36	237	207	194
	F-test	S.Em.(±)	C.D@5%	F-test	S.Em.(±)	C.D@5%
Depth (0-15cm)	S	0.005356	0.015913	S	2.965617	8.811301
Depth (15-30cm)	S	0.005727	0.017015	S	3.620043	10.75570
Depth (30-45cm)	S	0.018892	0.013723	S	3.508801	10.42518

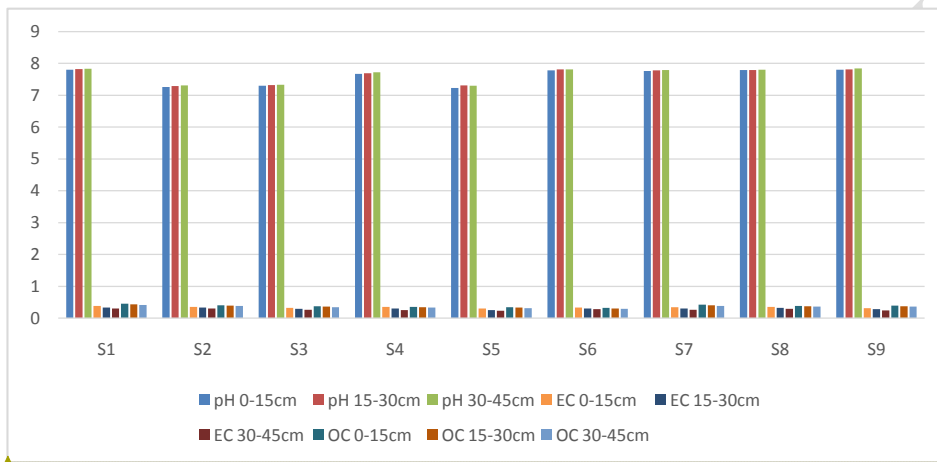
Table6: Available Phosphorus and Potassium (kg ha^{-1}) of soil in different villages of Phulpur block of Prayagraj district at 0-15cm, 15-30cm and 30-45cm depth

Villages	Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	0-15cm	15-30cm	30-45cm	0-15cm	15-30cm	30-45cm
V1	19.00	14.60	13.00	158	140	132
V2	21.00	17.89	14.60	169	156	141
V3	19.56	16.87	13.10	165	154	146
V4	18.00	16.45	12.20	230	219	207
V5	17.40	14.40	12.20	203	195	177
V6	22.50	19.20	16.10	191	171	159
V7	17.70	12.60	11.10	231	216	194
V8	15.00	12.33	10.80	225	214	192
V9	17.00	15.56	11.20	159	140.5	135
	F-test	S.Em.(±)	C.D@5%	F-test	S.Em.(±)	C.D@5%
Depth (0-15cm)	S	0.281225	0.835561	S	3.081863	9.156684
Depth (15-30cm)	S	0.216823	0.644215	S	2.545029	7.561670
Depth (30-45cm)	S	0.308520	0.916659	S	2.427219	7.211638

Villages	Exchangeable Calcium			Exchangeable Magnesium		
	(Meq 100g^{-1})			(Meq 100g^{-1})		
	0-15cm	15-30cm	30-45cm	0-15cm	15-30cm	30-45cm
V1	4.00	3.81	3.48	2.07	1.91	1.79
V2	4.40	4.10	3.77	2.44	2.31	2.13
V3	4.10	3.84	3.62	2.55	2.35	2.23
V4	5.20	4.90	4.70	2.72	2.55	2.39
V5	5.50	5.20	4.90	2.65	2.49	2.30
V6	5.15	4.93	4.61	2.16	1.92	1.80
V7	4.75	4.54	4.29	2.00	1.87	1.76
V8	4.11	3.85	3.63	1.94	1.78	1.66
V9	4.76	4.52	4.31	2.07	1.91	1.79

	F-test	S.Em.(±)	C.D@5%	F-test	S.Em.(±)	C.D@5%
Depth (0-15cm)	S	0.06334	0.188192	S	0.027845	0.082731
Depth (15-30cm)	S	0.08778	0.240301	S	0.031072	0.092318
Depth (30-45cm)	S	0.54626	0.162301	S	0.031052	0.092261

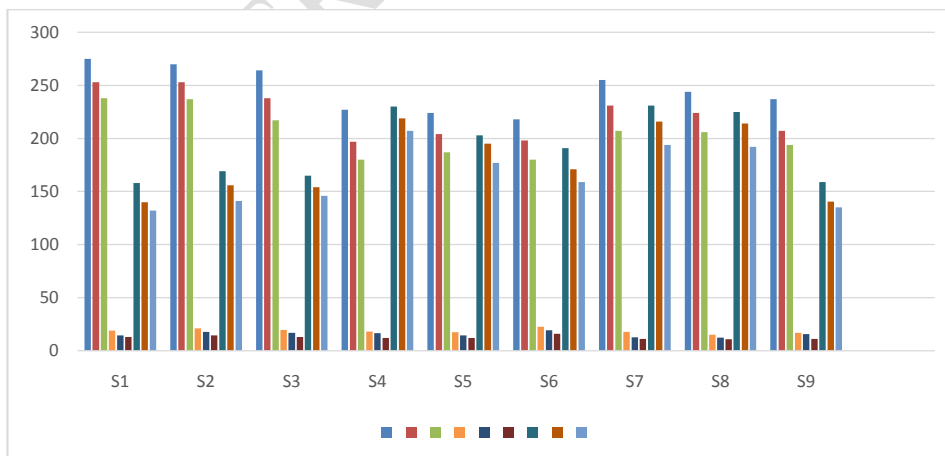
Table7:ExchangeableCalciumandMagnesiumofsoilindifferentvillagesofPhulpur block of Prayagraj districtat0-15cm,15-30cm and30-45 cmdepth



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Fig.3:SoilpH,EC and Organic Carbon ofsoilindifferentvillagesofPhulpur block of Prayagraj districtat0-15cm,15-30cm and30-45 cmdepth



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Fig.4: Available Nitrogen, Phosphorus and Potassium of soilindifferentvillagesofPhulpur

block of Prayagraj district at 0-15cm, 15-30cm and 30-45 cm depth

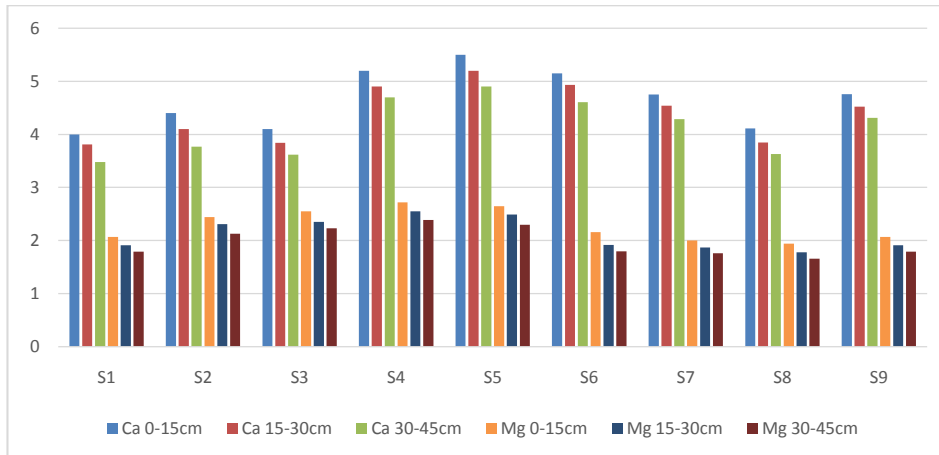


Fig.5: Exchangeable Calcium and Magnesium of soil in different villages of Phulpur block of Prayagraj district at 0-15cm, 15-30cm and 30-45 cm depth

3.3 Chemical properties of water

The pH of water varied from 6.24 to 7.50. The Electrical-electrical Conductivity-conductivity of water ranged from 0.31 to 0.90 dS m⁻¹

¹. The Bicarbonate bicarbonate of water varied from 7 to 18 Meq L⁻¹.

The chloride of water varied from 4.5 to 10.4 Meq L⁻¹. The Available-available calcium of water varied from 4.2 to 8 kg ha⁻¹. The Available-available Magnesium of water varied from 2.5 to 3.6 kg ha⁻¹. The Potassium of water varied from 0.05 to 0.17 Meq L⁻¹. The Sodium of water varied from 0.08 to 0.21 Meq L⁻¹ respectively. The Sodium Absorption Ratio (SAR) values ranged from 0.03 to 0.1 Meq L⁻¹, indicating low to moderate levels of sodium content in the water samples. The soluble sodium percent (SSP) values ranged from 1.47 to 3.93 Meq L⁻¹, providing further insight into the sodium content in the water. The residual sodium carbonate (RSC) values varied from -2.4 to 7.4 Meq L⁻¹. The Permeability Index (PI) values ranged from 28 to 56 Meq L⁻¹, serving as an indicator of the potential impact of water on soil permeability. Lastly, the Kelley's ratio (KR) values ranged from 0.08 to 0.024 Meq L⁻¹. The KR is a measure of the sodium hazard in irrigation water, with lower values indicating a lower risk of sodium-related issues in soil and crops.

Table 8 : Results of Irrigation Water Quality Parameters of Phulpur block in Prayagraj district.

Village	pH	EC (d Sm ⁻¹)	CO ₃ ²⁻ (Meq L ⁻¹)	HCO ₃ ⁻ (Meq L ⁻¹)	Cl ⁻ (Meq L ⁻¹)	Ca (Meq L ⁻¹)	Mg (Meq L ⁻¹)	Ca+Mg (Meq L ⁻¹)	K ⁺ (Meq L ⁻¹)	Na ⁺ (Meq L ⁻¹)
V1	7.5	0.9	0	10	9.2	9.2	3.4	8	0.12	0.1
V2	7.14	0.83	0	9	9.2	10.2	3.2	5.6	0.15	0.2
V3	6.24	0.31	0	13	10.4	8.4	3.6	7.4	0.17	0.1
V4	6.68	0.33	0	7	10.4	10.4	2.8	4.6	0.15	0.1
V5	6.4	0.53	0	18	10.8	10.2	3.6	7	0.1	0.0
V6	7.37	0.75	0	8	10.4	4.6	2.7	4.2	0.05	0.2
V7	6.9	0.35	0	12	8.4	10.4	3.1	5.3	0.07	0.1
V8	7.23	0.92	0	9	7.2	4.5	2.5	6.7	0.09	0.1
V9	7.28	0.72	0	14	8.8	9.6	3.2	6.8	0.07	0.0
F- test	S	S	NS	S	S	S	S	S	S	S
S.Em.(±)	0.95457	0.011479	-	0.175286	0.11492	0.088363	0.034269	0.06968	0.001428	0.001
C.D.@5%	0.28491	0.34104	-	0.520801	0.341445	0.262541	0.101818	0.47893	0.004243	0.004

Table 9-9: Results of Irrigation Water Quality Parameters of Phulpur block in Prayagraj district.

Village	SAR (Meq L ⁻¹)	SSP (Meq L ⁻¹)	KR (Meq L ⁻¹)	PI (Meq L ⁻¹)	RSC (Meq L ⁻¹)	IQWI (Meq L ⁻¹)
V1	0.07	2.48	0.015	29	-1.4	44
V2	0.1	3.93	0.024	34	0.2	110
V3	0.06	2.83	0.014	39	2	140
V4	0.09	3.59	0.021	36	-2.4	115
V5	0.03	1.67	0.008	56	7.4	121

V6	0.1	2.84	0.024	28	-0.9	57
V7	0.04	1.47	0.009	47	0.6	78
V8	0.05	2.23	0.013	33	-0.2	134
V9	0.03	1.48	0.008	47	4	154
F- test	S	S	S	S	S	S
S.Em.(±)	0.001211	0.03453	0.000214	0.018542	0.04866	0.34587
C.D.@5%	0.003599	0.102594	0.000635	0.055093	0.144577	0.37446

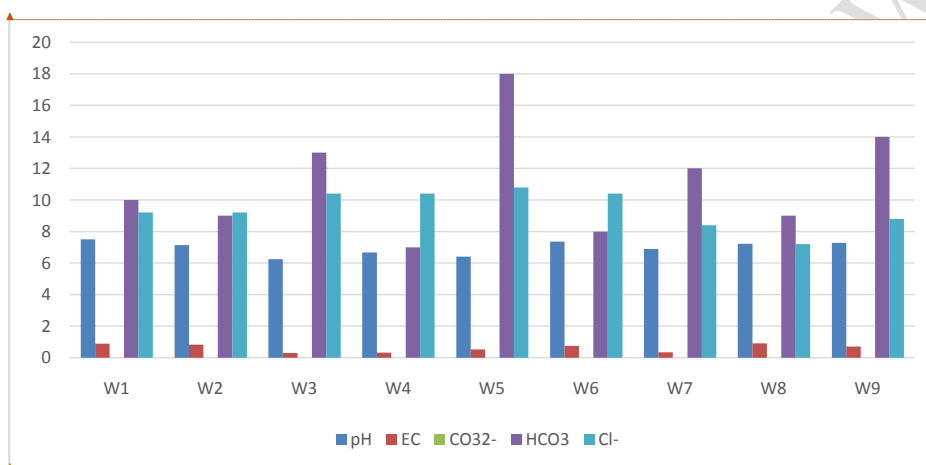


Fig.6: pH, EC, CO₃²⁻, HCO₃, Cl⁻ of water sample different villages of Phulpur block of Prayagraj district.

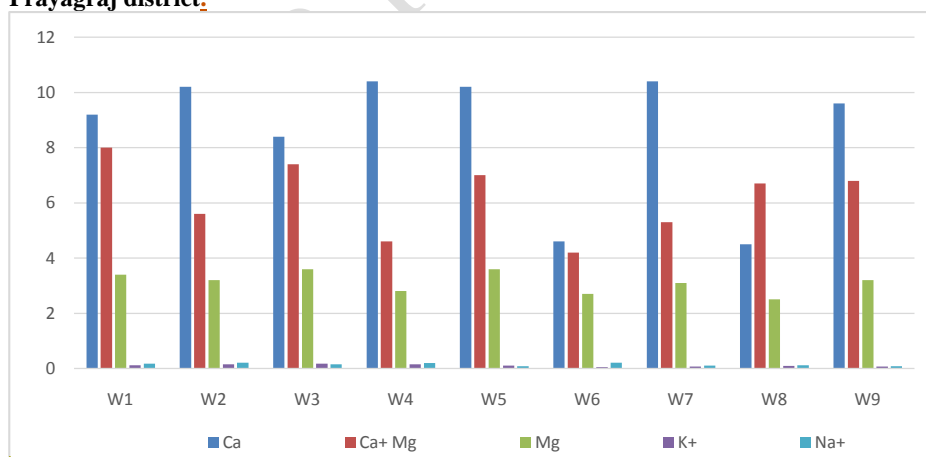


Fig.7: Ca, Mg, Ca+Mg, K⁺, Na⁺ of water sample different villages of Phulpur block of Prayagraj district.

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3. Conclusion

It is concluded that both the red soils and black soils were moderately to strongly alkaline in reaction and non-saline. On the soil complex the dominant cation is calcium. The physical properties of both surficial and sub-surficial soils are normal as the bulk density value is normal. The Water Holding Capacity is high. The overall fertility status of the soils was low, medium and high in nitrogen, phosphorus and potassium respectively. As the soils were calcareous and strongly alkaline, there is need for application of any acid forming amendment improves and organic materials to alleviate the nutrient deficiency and improve productivity of soils. The water pH was found to be slightly acidic to neutral and all the water sample shown very low sodium hazard. Alkalinity of water samples have shown 77.77% of sample are suitable and 33.33% of samples are not suitable for irrigation. Total hardness of the water samples was moderate range of soluble salts in water sample indicated moderately suitable for irrigation. Irrigation water quality index sample have shown 100% of the samples were in good condition for irrigation purpose.

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