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Research Article

DELINEATION OF PHYSICO-CHEMICAL STATUS OF KATAHAL NULLAH (BALLIA) WATER AND NEARBY SOIL

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Abstract: An investigation was carried out for physico-chemical status of Katahal Nullah water and nearby Nullah bank soil. The soil and water of four villages (Sanichari Mandir, Bedua, Nihora nagar and Chhorahar) pH and EC was appeared in alkaline and normal range. Organic carbon content varied low to high (0.18 to 0.90 %) and $CaCO_3$ moderately calcareous (2.12 % to 4.60 %). Available N, P, K and S were varied respectively (180.0 to 190.6 kg ha^{-1}), (13.63-14.80 kg ha^{-1}), (212.8-257.6 kg ha^{-1}) and (22.50 to 23.75 kg ha^{-1}) in increasing range. Micronutrients Fe, Cu, Zn and Mn were varied (1.13-3.20 mg kg^{-1}), (8.26 - 23.70 mg kg^{-1}), (0.16-1.94 mg kg^{-1}) and (6.16-19.33 mg kg^{-1}) in considerable range respectively. Similarly in water sample exchangeable Ca^{++} was varied from 5.0 to 10.0 cmol (p^+) kg^{-1} and magnesium content of the samples was ranged from 3.0 to 6.0 [cmol (p+) kg^{-1}]. The content of CO_3= and HCO_3- were not detectable in samples except Chhorahar village (10.0 meL^{-1}, 8.0 meL^{-1}). Micronutrients Fe, Cu, Zn and Mn in water sample were varied (0.16–0.49 ppm), (0.05-0.14 ppm), (0.05-0.06 ppm) and (0.09-0.22 ppm) respectively.

Keywords: Physical and chemical properties of soil, Micronutrients

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Introduction

Irrigation of vegetable crops by city sewage water or effluents in peri urban area is very common. That sewage water or effluents resulted very good and attractive produce due to excess amount of nitrate, phosphate, carbonate and some metallic contaminants [1]. After that, they are enter in human and animal food chain by this path way. Similarly, Katahal Nullah is a perennial waterline of Ballia city which is connected to river Ganga and Suraha Tal with the about 19 km length. It is main outlet of Ballia city water and effluent disposal. Farmers of the Katahal Nullah bank area villages *viz*. Sanichari Mandir, Bedua, Nihora nagar, Mahabir ghat and Chhorhar around Ballia city are being using Nullah water for irrigation purpose to produce cereals, fodder and vegetable crops mainly cauliflower, radish, spinach, brinjal *etc*. The study area is continuously irrigation with sewage sludge dominated effluent for more than three decades. The present study was undertaken to know the magnitude of contaminants in soil and water which are enter in crop plants.

Materials and methods

Study area-The study area in Ballia district lies between the parallel of 25°33' and 26°11'N latitude and 83°38' and 84°39'E longitude and 63 m of the sea level. The mean annual rainfall ranges from 950–1150 mm. The soils of this area are black alluviate to sandy loam alluvial in nature and it is typically to Indo-Gangatic plain soil. Collection of samples -Soil and water samples were collected from wet land area of Hanumanganj Block (Ballia) soils from the field of well cultivated area. Sampling sites were carefully chosen taking into consideration the ground cover, micro relief, degree of erosion, surface drainage, proximity to stress and all other factors likely to affect the soil in comparison with the normal type. Soil samples were collected from four villages namely; Sanichari Mandir, Bedua, Nihora Nagar and Chhorahar are away from Hanumanganj Block (25°75'85'' latitude and 84°15'longitude), 8.2 km (25075'19" latitude and 84015'37" longitude), 9 km (25075'17" latitude and 84016'02" longitude) respectively. Water samples were also collected respectively village including Mahabir Ghat (25075'25" latitude and 84015'49" longitude) and Chhorhar (25079'83" latitude and 84015'87" longitude).

Soil samples were collected by the help of Khurpi, scale and polythene bag, Water samples were collected in pre-cleaned bottle, preserved and analyzed according to standard methods. Soil available nitrogen was determined by alkaline potassium permanganate method [2]. Available P was estimated by using Olsen's *et al*. method (1954) [3] and for available K, N nutral ammonium acetate method described by Muhr *et al*. (1965) [4]. Available sulphur content of soil was determined by Williams and Steinberg (1969). The determination of chloride is easily made by $AgNO_3$ titration (Mohr's titration) method. After well processed soil samples were ready to analysis of targeted possible parameters in the laboratory of Department of Agricultural Chemistry and Soil Science, S.M.M. Town P.G. College, Ballia, only Fe, Cu, Zn and Mn analysis were done in Soil Testing Lab, Azamgarh (U.P.). About 1.5-2.0 kg of fresh soil samples were separately processed and air dried, powdered and sieved through 2 mm brass sieve and stored separately in polythene bag for physico-chemical analysis. The sufficient amount of 2L of collected water samples from all different sites were analysis for pH, EC, exchangeable Ca^{++} and Mg^{++}, CO_3= , HCO_3- , Cl-, exchangeable Na^+, SAR, RSC, Fe, Cu, Zn and Mn by standard procedure sited by Tandan (2005).

Results and discussions

Physical and chemical properties of soil

Bulk density of soil was measured [Table-1] in samples taken from four sites, it was varied between 1.13 to 1.83 Mg m^{-3} among the Sanichari Mandir, Bedua, Nihora nagar-1 and Nihora nagar-2 respectively. The slight variation on increased bulk density of Nihora nagar-1 due to cultivation practices might be leads to soil minerals composition but, use of imbalance fertilizer and very less use organic manure. The water holding capacity [Table-1] varied from 39.90 % to 48.30 %, the sample of Sanichari Mnadir was showed 48.30%, Bedua village samples were showed 45.50%, 39.90% and 48.30% samples of Nihora nagar-1, Nihora nagar-2 respectively. There are small differences of water holding capacity among the all four sites of different Nullah bank area villages.

Table-1 *Physico-chemical properties of soil*

Parameters	Sanichari Mandir	Bedua	Nihora nagar-1	Nihora nagar-2
pH	7.8	8.3	7.9	8.0
EC (dSm^{-1})	1.004	1.005	1.004	1.004
Bd (mg m^{-3})	1.62	1.32	1.83	1.13
WHC (%)	48.30	45.50	39.90	48.30
Organic Carbon (%)	0.18	0.56	0.90	0.37
Exchangeable Ca^{++}[cmol (p^+) kg^{-1}]	6.0	5.0	6.0	6.0
Exchangeable Mg^{++}[cmol (p^+) kg^{-1}]	4.0	2.0	4.0	3.0
$CaCO_3$ (%)	2.12	3.56	3.55	4.60

Table-2 *Available macro and micro nutrients in soil of different villages*

Parameters	Sanichari Mandir	Bedua	Nihora nagar-1	Nihora nagar-2
Available Nitrogen (kg/ha)	180.0	183.80	180.80	190.60
Available Phosphorus (kg/ha)	14.32	13.63	14.80	14.28
Available potassium (kg/ha)	212.8	246.4	257.6	224.0
Available Sulphur (kg/ha)	22.50	23.75	22.50	22.50
DTPA extractable Fe (mg/kg)	3.20	2.57	1.13	1.97
DTPA extractable Cu (mg/kg)	9.06	8.84	23.70	8.26
DTPA extractable Zn (mg/kg)	0.16	0.50	1.94	0.48
DTPA extractable Mn (mg/kg)	6.16	19.33	5.12	13.81

Table-3 *Physico-chemical properties of water and DTPA extractable micronutrients ($mgkg^{-1}$) in different villages water samples of Katahal Nullah*

Parameters	Sanichari Mandir	Bedua	Mahabir ghat	Chhorahar
pH	7.40	6.94	7.67	7.80
EC (dSm^{-1})	1.008	1.007	1.007	1.009
Ca^{++}[cmol (p^+) kg^{-1}]	5.0	5.0	6.0	10.0
Mg^{++}[cmol (p^+) kg^{-1}]	3.0	3.0	4.0	6.0
CO_3 ($meqL^{-1}$)	Not detectable	Not detectable	Not detectable	10.0
HCO_3 ($meqL^{-1}$)	Not detectable	Not detectable	Not detectable	8.0
Chloride ($meqL^{-1}$)	6.4	7.2	8.0	6.0
Na (meq L^{-1})	0.33	0.37	0.35	0.45
SAR (meq L^{-1})	0.16	0.18	0.15	0.15
RSC (meq L^{-1})	Not detectable	Not detectable	Not detectable	Not detectable
Fe(ppm)	0.42	0.49	0.28	0.16
Cu (ppm)	0.14	0.0	0.14	0.14
Zn (ppm)	0.05	0.05	0.05	0.06
Mn (ppm)	0.15	0.09	0.22	0.11

Soil pH [Table-1] from Sanichari Mandir, Bedua, Nihoranagar-1 and Nihoranagar-2 were ranged between 7.8 to 8.3. The increasing range of pH towards alkaline from Sanichari Mandir to Bedua were found in all sample site in surface soil. The sewage water irrigated soils, in general, had high pH [5]. Electrical conductivity of soil [Table-1] showed higher the ionizable solids, greater will be the EC. The study area varied in the range of 1.007 dSm^{-1} to 1.009 dSm^{-1} with an average value of 1.008 dSm-1. The continuous irrigation with sewage effluent for more than three decades has not considerable value of electrical conductivity of sewage irrigated soil which was much below the threshold limit of salinity [6] The organic carbon content (%) at different surface soil samples of all four villages [Table-2] was ranged between 0.18 to 0.90 %. The surface soil samples from four sites of treated sewage water and adjoining tube well irrigated areas were showed lower pH and EC but higher organic carbon in comparison to tube well irrigated soils [7]. It was found that increase in organic matter content and interactions of the metals with the organic content (adsorption and complex formation) are the reasons for high values of the tested constituents in soil after the refuse is dumped in soil [8]. Available nitrogen content in soil were showed [Table-2] increasing range from 180.0 to 190.6 kg/ha, throughout the all soil samples. Use of sewage water for irrigation on improved chemical properties and fertility status in soil. Sewage water contains essential elements for plant growth and also contains heavy metals which might be toxic for animals if their concentration exceeds. The sewage water was found in permissible amount of total N, P and K [9]. Available phosphorus content in soil varied between 13.63-14.80 kg/ha [Table-2]. Available potassium content [Table-2] in soil sample ranged between 212.8-257.6 kg/ha. Greater soil potassium (257.6 kg/ha) content was observed in Nihoranagar-1 soil sample than the minimum soil potassium (212.80 kg/ha) content was observed in Sanichari Mandir soil sample. Moreover, there were amount was decreasing due to water resources which use waste water in agriculture as on alternative sources of water and nutrients is being debated [10]. Similarly, available sulphur [Table-2] content in soil at Sanichari Mandir was showed 22.50 Kg/ha, Bedua soil sample was showed 23.75 Kg/ha. Soil sample of Nihora nagar-1 and Nihora nagar-2 was 22.50 mg kg^{-1}, 22.60 mg kg^{-1} respectively. Greater amount of available sulphur was resulted from its recycling over the years by plant and subsequent organic matter accumulation. The amount of exchangeable calcium [Table-1] of Nullah bank area villages have appeared lower amount of exchangeable calcium, 5.0 [cmol (p^+) kg^{-1}] in Bedua soil sample. 6.0 [cmol (p^+) kg^{-1}] was recorded in Sanichari Mandir, Nihora nagar-1 and Nihora nagar-2 soil sample respectively. Therefore amount of exchangeable Ca has not detrimental because of it is one of the important nutrients required to all organisms (Vyas, 2011). Magnesium content of the soil samples analyzed ranged between 2.0-4.0 [cmol (p^+) kg^{-1}] [Table-1]. The higher content of magnesium was 4.0 [cmol (p^+) kg^{-1}] in surface soil sample at Sanichari Mandir and Nihora nagar-1. The major sources of magnesium are various kinds of pollutants and contaminants in the area. The high concentration of calcium and magnesium are appeared due to related clay minerals such as illite and chlorite. Total hardness as $CaCO_3$ varied from 2.12 % to 4.60 % [Table-1]. The highest desirable limit of total hardness as $CaCO_3$ in soil sample was 4.60 % of Nihoranagar-2. It is well known that hardness is not caused by single substances but might be the variety of dissolved polyvalent metallic ions, predominantly with calcium and magnesium cation.

Micronutrients

DTPA extractable Fe [Table-2] in surface soil was ranged from 1.13 - 3.20 mg/kg of soil of all Katahal Nullah bank villages. However, available Fe content was found maximum 3.20 mg/kg in soil of Sanichari Mandir, while lowest Fe content 1.13 mg/kg was measured at Nihoranagar-1 soil sample. Among the villages 3.56 mg/kg, 1.97 mg/kg was found in respectively Bedua and Nihoranagar-2 soil sample. Available Cu (DTPA extractable) in soil were [Table-2] showed range from 8.26 to 23.70 mg/kg of all villages.

Survey works

Although the lowest Cu content was measured 8.26 mg/kg at Nihora nagar-2 soil sample. At Sanichari Mandir soil sample was found 9.06 mg/kg, while Bedua village showed 8.84 mg/kg and 23.70 mg/kg found at Nihoranagar-1 soil sample. The greater value of available Cu might be attributed by house hold sewage. Available Zn in different [Table-2] soil sample were showed from 0.16-1.94 mg/kg in soil. The greater content was found 1.94 mg/kg in Nihora nagar-1 and the lower content was found 0.16 mg/kg in Sanichari Mandir soil sample. Available Zn in all soil sample varied from 0.16 to 1.94 mg/kg but 0.48 mg/kg and 0.50 mg/kg found in Nihoranagar-2 and Bedua soil sample respectively. The greater amount of DTPA extractable Zn was found in same village due to house hold sewage and effluents. The available Mn content in soil sample of Sanichari Mandir was found 6.16 mg/kg, at Bedua 19.33 mg/kg, at Nihoranagar-1 5.12 mg/kg and in soil sample of Nihoranagar-2 was recorded 13.81 mg/kg on surface soil. Inspite of this the greater content was observed at Bedua 19.33 mg/kg and the lowest value 5.12 mg/kg was seen in soil sample of Nihoranagar-1. The greater amount of DTPA extractable Cu, Mn and Zn in soils of different villages might be due to excess tillage practices and chemical fertilizers which are leads to increase their available forms.

Physico-chemical properties of water

The pH of water [Table-3] showed that from Katahal Nullah bank area village *viz*. Sanichari Mandir, Bedua, Mahabir ghat and Chhorahar were ranged from 6.94 to 7.80. The increasing range of pH towards alkaline from Mahabir ghat to Chhorahar were found in all site of water sample.

Higher pH was due to the redox exchanges in the sediments and water column, apart from the influence of fresh water. The EC of water [Table-3] varied in the range of 1.007 to 1.009 dSm^{-1} with an average value of 1.008 dSm-1. Electrical conductivity is measure of salinity with greatly affects the taste and thus has a significant impact on the user acceptance of the water as potable [11]. Total Calcium content in water samples was ranged from 5.0 to 10.0 [cmol $(p^+)kg^{-1}$] [Table-3]. Maximum calcium content found in Chhorahar village water sample while lower value was seen in two water samples at Sanichari Mandir and Bedua. High concentration of calcium are not desirable in washing, laundering and bathing owing to its suppression of formation of leather with soap scale formation in utensils and boilers. It coagulates with soap and makes dirty layers on sinks and basins [12]. Magnesium content [Table-3] in water samples was ranged from 3.0 - 6.0 [cmol (p^+) kg^{-1}]. The principal sources of magnesium are various kinds of pollutants in the area. In low concentration, it is non-toxic. However, it adds to hardness of water. The carbonate content was [Table-4] was not detected in most of the water samples throughout the study. Therefore, the total alkalinity is mostly due to the presence of bicarbonate [11] Concentration of carbonate and bicarbonate were appeared only in water sample of Chhorahar village-CO_3 (10.0 $meqL^{-1}$) and HCO_3 (8.0 $meqL^{-1}$), therefore observed values of the water samples are within the permissible limit and are safe for irrigation purpose. Chloride occurs naturally in all types of water, in the study area ranged between 6.0 to 8.0 ($meqL^{-1}$). Higher chloride content was recorded in water sample site of Mahabir ghat -8.0 (meq L^{-1}) whereas minimum value 6.0 (meq L^{-1}) observed in Chhorahar [Table-3] site water sample. The potential risks of waste water reuse have been found as the increased insect attack, diseases and excessive weed problem. Sometimes excess waste water used for irrigation or short-term waterlogging in the area eventually leads to crop damage [13]. Exchangeable sodium concentration of the samples was ranged between 0.33 to 0.45 (meq L^{-1}) with an average value of 0.35 ($meqL^{-1}$). The higher concentration 0.45 ($meqL^{-1}$) was found in Chhorahar and the lower concentration 0.33 ($meqL^{-1}$) was found in water sample site of Sanichari Mandir. SAR value was ranged from 0.15 $meqL^{-1}$ to 0.18 $meqL^{-1}$ [Table-3]. There is close relationship between SAR values in irrigation water and the extent to which Na+ is absorbed by soil. If water used for irrigation under high content of sodium and low in calcium, the ion exchange complex may become saturated with sodium, which destroys soil structure, because of dispersion of clay particles. RSC value has hazardous effect of carbonate and bicarbonate on the quality of water for crop cultivation purpose. RSC remained not detectable for most of the water samples which showed that water was within the limit (<2.5) for use in irrigation. The increase of RSC in ground water is significantly harmful for plant growth.

Micronutrients

DTPA extractable Fe in water samples [Table-3] were ranged from 0.16-0.49 ppm of various sites. Some of the heavy metals like Fe, Cu, Zn and Mn are essential as micronutrient for plants, microbes and human beings. However, available Fe content was found maximum (0.49 ppm) in water sample of Bedua sites and 0.42 ppm, 0.28 ppm were found in Sanichari Mandir and Mahabirghat water sample respectively. Similarly, content of Cu was [Table-3] appeared in water sample of Nullah bank area villages; Sanichari Mandir, Bedua, Mhabir ghat and Chhorahar. Presence of metal ions such as Zn, Mn, Fe and Cu in agricultural inputs especially, sewage sludge might be gradually built up their concentration in soil [14]. DTPA extractable Zn in [Table-3] water sample were ranged from 0.05 - 0.06 ppm of various sites. Most of the water samples were showed the concentration was 0.05 mg/kg at Sanichari Mandir, Bedua and Mahabir ghat respectively. Only Chhorahar village water sample was showed 0.06 mg/kg of DTPA extractable Zn concentration. The amount of DTPA extractable Mn in water sample [Table-3] of Sanichari Mandir was showed 0.15 ppm, Bedua water sample showed 0.09 ppm. Mahabir ghat sample showed 0.22 ppm and 0.11 ppm was found in Chhorahar sites water sample. The maximum concentration was recorded in Mahabir ghat (0.22 ppm), whereas minimum content (0.09) was found in Bedua site water sample. Heavy metals appeared enter the soil through various sources which has becides affecting plant growth also ultimately affect soil microorganisms and microbial processes responsible for nutrient cycling [15-19].

Conclusion

Studies have showed that, the soil and water characteristics at various place and parameters were appeared in considerable range. Water samples of Chhorahar village showed greater amount of exchangeable Ca+ and Mg+, pH, EC, carbonate and bicarbonate, SAR, RSC among the villages. Variation in major soil properties such as soil pH, some extant of electrical conductivity, bulk density, water holding capacity, soil organic carbon, calcium carbonate, available N,P,K, and S, exchangeable Ca^{++} and Mg^{++}, DTPA extractable micronutrients as Fe, Cu, Zn and Mn were found in under considerable range. Soil sample site Bedua and Chhorahar village showed greater amount of pH, EC, water holding capacity, soil organic carbon, available N and S, exchangeable Ca^{++} and Mg^{++}, calcium carbonate, while variable amount of available Fe, Cu, Zn and Mn observed in surface soil (0-15 cm) of all villages. So, natural vegetation along with duration of water leads to accumulation of organic matter as well as other plant nutrients in soil. It has strongly influence on Nullah bank area of village, soil and water properties for development of vegetable cultivation in peri-urban area of Ballia city that leads to the quality of soil and water. Soil and water sample investigation and subsequent analysis have determined relationship between water quality features and soil properties of peri-urban area of Ballia city.

Application of research: Study the information about to the running water quality which are using by farmers for irrigation water in vegetable crops nearby city area. The savage water of city is reaching in Ganga water body and will be provide the alertness for future planning.

Research Category: Soil Water Pollution

Abbreviations: mg-Milligram, ppm-parts per million, meqL-1- milli equivalent per litter, kg/ha-Kilogram per hectare, BD-Bulk Density, EC-Electrical Conductivity, WHC-Water Holding capacity

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Study area / Sample Collection: Nearby city of Ballia, Uttar Pradesh

Cultivar / Variety / Breed name: Cabbage, Tomato, Garlic, Spinach, Sugerbeet

Conflict of Interest: None declared

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References

[1] Jeyabhaskaran K.J. and Ramulu Sree U.S. (1996) *Journal of the Indian Society of Soil Science*, 44(3), 401-404.
[2] Subbiah B.V. and Asija G.L. (1996) *Current Science*, 25, 259.
[3] Olsen's S.R., Cole C.V., Watanable F.S. and Dean L.A. (1954) *United States Department of Agriculture Circular* 939.
[4] Muhr G.R., Datta N.P., Sankarasubramony H., Laley V.K. and Donahure R.L. (1965) *Soil Testing in India USAID, New Delhi*.

[5] Taywade S.S and Prasad Jagdish (2008) *Journal of the Indian Society of Soil Science*, 56(3), 247-253.
[6] Kharche V.K., Desai V.N. and Pharande A.L. (2011) *Journal of the Indian Society of Soil Science*, 59(2), 177-184.
[7] Tiwari R.C., Saraswat P.K. and Agrawal H.P. (2003) *Journal of the Indian Society of Soil Science*, 51(2), 150-155.
[8] Jeyapriya S.P. and Sasheetharan M.K. (2010) *J. Pollution Research*, 29(1), 37-41.
[9] Mohammed A., Alghobar Lathamani., Ramachandra Sidduraiah Suresha (2014) *American Journal of Environmental Protection*, 3(5), 283-291.
[10] Tak Hamid I., Babalola Olubukola O., Huyser Maria H. and Inam Arif (2013) *Soil science and Plant Nutrition*, 59(2), 156-167.
[11] Tank Dinesh Kumar and Chandel Singh C.P. (2011) *J. Pollution Research*, 30(2), 187-193.
[12] Vyas P.B. (2011) *J. Pollution Research*, 30(2), 161-163.
[13] Roy S., Banna L.N., Mamun S.A. and Farukh M.A. (2013) *Bangladesh Agriculture University*, 11(2), 183-188.
[14] Saha R.N., Satpati S., Bardhan R., Gupta S. and Datta J.K. (2010) *J. Pollution Research*, 29(1), 77-82.
[15] Banger K.C. (2003) *Journal of the Indian Society of Soil Science*, 51(4), 473-483.
[16] Chhonkar P.K., Datta S.P., Joshi H.C. and Pathak H. (2000) *Journal of Scientific and Industrial Research*, 59,350-361.
[17] Kanwar J.S., and Chopra S.L. (1998) *Analytical Agricultural Chemistry (Edn.) Kalyani Publishers, New Delhi.*
[18] Piper C.S. (1966) *Soil and Plant Analysis. Published by Hans Publication, Bombay.*
[19] Walkley A. and Black I.A. (1993) *Soil Science*, 37, 29-38.