INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–2–264–267
http://www.ijab.org

NPK Status in Effluent Irrigated Soils of Some Selected Sites of NWFP

MIDRAR-UL-HAQ, RIAZ A. KHATTAK†, HAJI KHAN PUNO AND M. SALEEM SAIF
Department of Soil Science, Sindh Agriculture University, Tandojam–Pakistan
†Department of Soil and Environmental Sciences, NWFP Agricultural University, Peshawar–Pakistan

ABSTRACT

This paper presents the accumulation of NPK in effluent irrigated soils of some selected sites of NWFP. Forty samples from each depth 0-20 and 20-40 cm were collected from soils possibly contaminated by the industrial effluent irrigation, while eight samples (four samples from each depth) were taken from soil irrigated with tube well water, considered as 'background soil'. The samples were collected both in summer and winter seasons of the years 2000 and 2001. All the soil samples were analyzed for physico-chemical properties and major elements (NPK). The soil samples were found alkaline in reaction, non-saline, moderately to highly calcareous in nature and low to adequate in organic matter content. The average values of NPK were 26.22, 16.92 and 94.16 mg kg^{-1} at 0-20 cm soil depth while 20.38, 10.6 and 76.15 mg kg^{-1} at 20-40 cm soil depth, respectively. However, the background soil values for NPK were 21.58, 8.39 and 95.22 mg kg^{-1} at 0-20 cm soil depth while 19.54, 6.39 and 73.72 mg kg^{-1} at 20-40 cm soil depth, respectively. The results showed significantly ($P<0.01$) higher level of NPK in surface soils compared to sub-surface soils.

Key Words: Effluents; Irrigation; NPK

INTRODUCTION

If a soil is to produce crops successfully, it must have, among other things, an adequate supply of all the essential elements or nutrients. If any of these elements is lacking, or if it is present in improper proportions, normal plant growth will not occur. Nitrogen (N), Phosphorus (P) and Potassium (K) are the major elements, which are required in relatively large amounts and can be termed as macronutrients (Foth, 1984). N has been studied directly or indirectly for centuries and is still the most studied element in soil fertility. It is the soil nutrient that most commonly limits plant growth (Hinrich *et al.,* 1985). N is essential for plant growth as it is constituent of all proteins and nucleic acids and hence of all protoplasm. It is generally taken up by plants either as ammonium or as nitrate ions (Russell, 1973). P plays an indispensable role as a universal fuel for all biochemical work in living cell while K has a counterbalancing effect on the results of nitrogen excess. It enhances carbohydrates synthesis and translocation (Foth, 1984).

Due to their vital role in plant growth, these nutrients are applied to the soil via commercial fertilizers to fulfill plant requirements for these elements. Besides commercial fertilizers, various domestic and industrial wastes also supply these elements to the soil. The usage of industrial and domestic effluents for irrigation is widely practiced in the urban areas of Pakistan. Being the rich source of nutrients, the continuous application of effluents may increase the build up of both macro and micronutrient in soil with time period. To detect the NPK status in effluent irrigated soils of some selected sites of NWFP, this study was conducted during the years 2000 and 2001. To compare the results with background values, some tubewell irrigated soil samples were also collected and analyzed for NPK.

MATERIALS AND METHODS

The soil samples were collected from some selected sites including Amangarh Industrial Area, Pirsabak Farm and Malakandair Farm. The Amangarh Industrial Area and Pirsabak Farm receive industrial effluents in irrigation water; while, Malakandair Farm was a tubewell irrigated farm. All the fields were cultivated with agricultural crops during the sampling period. The composite soil samples were collected in polythene bags from two depths (0-20 and 20-40 cm) with the help of stainless steel auger. The criteria for selection of the sampling sites were based on the possible contamination due to irrigation with industrial wastes waters. A total of 80 effluent irrigated soil samples (40 samples from each depth) were collected from Amangarh (16 samples) and Pirsabak (64 samples) while eight samples (four samples from each depth) were taken from soils irrigated with tubewell water considered as 'background soil'.

The samples were collected both in summer and winter seasons of the years 2000 and 2001 from the same locations. The soil samples brought to the laboratory were air dried, sieved (< 2 mm) and then analyzed for pH and EC by 1:5 soil water suspension method (Mc Lean, 1982; Rhoades, 1982), Lime by acid neutralization method (Richards, 1954), organic matter by Walkely and Black method (Nelson & Sommers, 1982), soil texture by

Bouyoucos hydrometer method (Gee & Bander, 1986), and soil major elements (NPK). The total mineral nitrogen and NO_3-N were determined by steam distillation method (Keeney & Nelson, 1982) while AB-DTPA extractable P and K by extraction method, using spectronic 601 and flame photometer, respectively (Havlin & Sultanpoor, 1981). To evaluate the effect of year, season and sampling depth, analysis of variance using 2^3 factorial RCBD was applied on the data for the concentrations of major elements (NPK) in soil samples collected from various sites of NWFP during summer and winter seasons of the years (2000-2001). The significance of results were tested by t-test (P<0.05) as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Table I provides the summary of the statistical analysis with given level of probability. The ANOVA showed significant variations within the given sites of sampling as evident from the level of probability and co-efficient of variations, which ranged from 11.45 to 66.44%. This observation is understandable as soil samples were collected from diverse locations.

Table II shows data for the concentrations of NPK in soil samples collected during summer and winter seasons of the years 2000 - 2001. The comparison of the mean values of soil major elements (NPK) in effluent irrigated soil samples (n = 40), with the concentrations in tube well irrigated soil samples (n = 4), based on t-test is provided in Table III. Table IV & V indicate classification of soil samples according to AB-DTPA soil P and K. However, Table VI shows the relationship of NPK with soil pH and organic matter. The data regarding soil physico-chemical properties is presented in Table VII.

Table I. Summary of ANVOA showing the effect of year, season and sampling depth on the concentrations of major elements (N, P, K) at the given level of probability

Sources of variation	Soil major elements (n=80)			
	TMN	NO_3-N	AB-DTPAext.P	AB-DTPAext.K
Year	0.145	< 0.001	> 0.15	0.056
Season	> 0.15	> 0.15	0.058	0.096
Depth	< 0.0001	<0.0001	0.003	< 0.0001

TMN= Total mineral nitrogen

Concentrations of N, P and K in soils. The concentrations of NPK in effluent irrigated soil samples collected from various sites of NWFP during summer and winter seasons of the years 2000 and 2001 have been given in Table II. Comparison of the average values of NPK in effluent and tube well irrigated (background) soil samples collected from various sites of NWFP has been given in Table III.

The analysis of variance showed that TMN and NO_3-N were significantly higher in surface soils than sub-surface soils (Table I). Such difference might be due to variations in organic matter content and microbial populations. Bolton *et al.* (1990) reported similar results about the decreasing concentrations of N in soil with respect to soil depth. The t-test comparison showed that the concentrations of TMN and NO_3-N in effluent irrigated soils were significantly higher than those in tube well irrigated soils (Table III). This variation in N concentration can be associated with a composition of industrial effluents and domestic sewage contained in irrigation water, removal by crop and a difference in soil physico chemical properties. Mineral N also responses to metal contamination, which are usually positive, and can be attributed to higher mineralization rates and the release of N from dead microbial cells (Bogomolov *et al.,* 1996) and decreased microbial immobilization (Westermann & Tucker, 1974).

Table II. Concentration of NPK (mg kg^{-1}) in effluent irrigated soil samples collected from various sites of NWFP during summer and winter seasons of the years 2000 and 2001

Soil Depth (cm)	Soil Major Elements	Values	Year 2000		Year 2001	
			Summer	Winter	Summer	Winter
0-20	TMN	Min	21.59	22.76	20.42	20.42
		Max	35.59	29.76	37.92	28.58
		Mean	25.91	26.49	26.72	25.78
	NO_3-N	Min	12.91	5.84	9.9	12.25
		Max	15.75	17.50	19.25	18.08
		Mean	12.37	13.65	15.17	15.05
	AB- DTPA Ext.P	Min	3.37	3.58	4.10	3.99
		Max	96.31	44.42	92.96	36.06
		Mean	20.59	13.88	20.80	12.39
	AB- DTPA Ext.K	Min	77.62	76.75	84.82	75.15
		Max	141.51	145.12	122.66	94.14
		Mean	97.72	95.43	96.85	86.64
20-40	TMN	Min	16.92	19.25	15.75	15.75
		Max	27.42	26.25	25.08	21.58
		Mean	20.77	21.94	19.71	19.13
	NO_3-N	Min	2.33	5.25	7.58	7.58
		Max	12.84	14.00	15.75	12.25
		Mean	7.12	10.33	12.19	10.38
	AB- DTPA Ext.P	Min	3.05	2.42	2.84	3.89
		Max	29.79	44.73	36.62	24.30
		Mean	10.69	11.41	10.86	9.44
	AB- DTPA Ext.K	Min	48.92	47.53	60.99	63.95
		Max	128.58	94.87	84.44	86.10
		Mean	87.21	72.89	69.83	74.65

TMN= Total mineral nitrogen; Ext.= Extractable

Table III. Comparison of the average values (mg kg^{-1}) of NPK in effluent and tube well irrigated (background) soil samples collected from various sites of NWFP

Soil Major Elements	Soil Depth (cm)	Effluent irrigated Soil mean values (n=40)	Tube well irrigated soil mean values (n=4)	t-value
TMN	0-20	26.22	21.58	5.41*
	20-40	20.38	19.54	1.59
NO_3-N	0-20	14.06	10.66	8.05*
	20-40	10.00	9.18	0.59
AB-DTPA Ext.P	0-20	16.91	8.39	2.88
	20-40	10.60	6.39	2.56
AB-DTPA Ext.K	0-20	94.16	95.22	0.42
	20-40	26.14	73.72	2.70

Tube well irrigated soil values are significantly lower than the mean values of effluent irrigated soils at P < 0.05; TMN= Total mineral nitrogen; Ext.= Extractable

Table IV. Classification of soil samples according to AB-DTPA extractable soil P

Classification	P^{ψ} Index Values (ppm)	NWFP (n=80) Depth (cm) 0-20 No. of samples	% of samples	20-40 No. of samples	% of samples
Low	0 – 3	1	2	10	25
Medium	4 – 7	16	40	14	35
High	8 – 11	7	18	7	18
Very High	> 11	16	40	9	22

Source: Havlin and Sultanpour (1981)

Table V. Classification of soil samples according to AB-DTPA extractable soil K

Classification	K^{ψ} Index Values (ppm)	NWFP (n=80) Depth (cm) 0-20 No. of samples	% of samples	20-40 No. of samples	% of samples
Low	0-60	-	-	3	7
Medium	61-120	37	93	36	90
High	> 120	3	7	1	3

Source: Havlin and Sultanpour (1981)

Table VI. Relationship of pH and soil organic matter with NPK

Independent variable	Soil depth (cm)	TMN r-value	TMN t-value	NO_3-N r-value	NO_3-N t-value	P r-value	P t-value	K r-value	K t-value
pH (1:5)	0-20	-0.16	0.97	-0.12	0.73	-0.21	1.32	-0.49	3.50**
	20-40	-0.48	3.41**	0.19	1.18	0.66	5.36***	-0.29	1.85
O.M	0-20	0.47	3.29**	0.10	0.62	0.86	10.5***	0.11	0.71
	20-40	0.51	3.69***	0.29	1.86	0.92	14.0***	0.21	1.35

, * Significant at P < 0.01 and 0.001, respectively

Table VII. Average values of soil physico-chemical properties of different soil samples collected from various sites of NWFP Province during different seasons of the years 2000 and 2001

Parameter	Soil Depth (cm)	2000 Summer (n=10)	2000 Winter (n=10)	2001 Summer (n=10)	2001 Winter (n=10)	Mean values (n=40)
pH	0-20	8.17	8.26	8.19	8.23	8.21
	20-40	8.06	8.24	8.11	8.21	8.15
EC (dSm^{-1})	0-20	0.22	0.17	0.25	0.22	0.22
	20-40	0.16	0.16	0.33	0.25	0.23
Lime (%)	0-20	14.55	12.92	12.75	12.90	13.28
	20-40	10.2	15.75	11.92	10.2	12.02
O.M (%)	0-20	1.09	1.03	1.10	1.26	1.12
	20-40	0.83	0.83	0.72	0.90	0.82

The analysis of variance showed that P was significantly higher in summer compared to winter and similarly, significantly higher in surface soils than sub-surface soils. While, according to t-test comparison the P in effluent and tube irrigated soils was non-significant which indicates that effluents application has not affected P in soils. According to categorization of Havlin and Sultanpour (1981), 2 and 25%, 40 and 35%, 18 and 18%, 40 and 22% of samples were categorized as low, medium, high and very high in P concentrations for 0-20 cm and 20-40 cm soil depth, respectively (Table IV).

Khattak and Rehman (1992) reported P concentration of 8.44-73.86 mg kg^{-1} for agricultural soils in Amangarh Industrial Area and 5.55-18.65 mg kg^{-1} for Pirsabak Farm while Rabi (1999) reported P concentration of 1.80 mg kg^{-1} for Pirsabak soils. The results indicated that the P concentration was higher in Amanagarh Industrial Area which receive concentrated form of the effluent than Pirsabak Farm. The reported values for the respective sites are in agreement with those observed by Khattak and Rehman (1992) but much higher than Rabi (1999) because Rabi reported the values of soils receiving the most diluted form of the effluents.

The analysis of variance showed that K is significantly affected by the difference in season and sampling depth at P<0.15 and 0.01, respectively (Table I). The t-test comparison showed that K in effluent and tubewell irrigated soil samples remained non-significant, which means that effluents irrigation has not affected K in soil. According to classification of Havlin and Sultanpour (1981), 93 and 7% samples were classified as medium and high in K concentration for 0-20 cm soil depth; while, 7, 90 and 3% were recorded as low, medium and high in K concentration for 20-40 cm soil depth.

The results indicated in Table II are quite comparable with those reported by Chaudhry *et al.* (1992) for canal and tubewell irrigated soils of Punjab. By considering the K value of 60 mg kg^{-1} as an index value, most of the upper soil samples (0-20 cm) contained appreciable amount of K; while, K is generally considered as safe element in the food chain.

Moreover, the concentrations of NPK in soil were also correlated with soil physico-chemical properties. The soil pH showed negative and non-significant correlation with N and P while significant with K at 0-20 cm soil depth. The N showed negative but P showed positive and significant correlation with pH at 20-40 cm soil depth while K showed negative and non-significant correlation. The organic matter content showed positive and significant correlation with N and P. The correlation between soil K and organic matter content was positive and non-significant at both depths. The variations in soil physico-chemical properties and their correlation with major elements (NPK) may be due to variations in composition of industrial effluents used for irrigation, changes in temperature, microbial activities, climatic conditions (rain fall) and other site related complex factors.

CONCLUSIONS

Based upon the above discussion, it can be concluded that effluent irrigation has significantly affected the accumulation of N in soil; while, P and K was not affected so much. The continuous application of effluents in irrigation water might disturb the NPK balance in soil and hence could affect crops production and quality.

REFERENCES

Bogomolov, D.M., S.K. Chen, R.W. Parmelee, S. Subler and C.A. Edwards, 1996. An ecosystem approach to soil toxicity testing: a study of copper contamination in laboratory soil microorganisms. *Appl. Soil Ecol.*, 4: 95–105

Bolton, H.Jr., J.L. Smith and R.E. Wildung, 1990. Nitrogen minieralization potentials of shrub–steppe soils with different disturbance histories. *Soil Sci. Soc. Am. J*. 54: 887–91

Chaudhry, A.R., G. Hussain and D.M. Malik, 1992. Crop response to potash application in Punjab. *Annual Report* 1991–92. Soil fertility survey and soil testing institute, Lahore

Foth, H.D., 1984. *Fundamentals of Soil Science,* pp: 287–315. John Wiley & Sons, Inc. USA

Gee, G.W. and J.W. Bander, 1986. *Particle Size Analysis. In:* Kiute, A. (eds.) *Methods of Soil Analysis*, Part 1, 2nd ed., p. 383–411. American Society of Agronomy, Madison WI

Hameed, A., 1991. Study of the micronutrient status of some important sites of N.W.F.P. *M.Sc. (Hons.) Thesis,* Department of Soil Science, NWFP Agriculture University, Peshawar–Pakistan

Havlin J.L. and P.N. Soltanpour, 1981. Evaluation of the NH_4 HCO_3–DTPA soil test for iron and Zinc. *Soil Sci. Soc. Am. J*., 45: 70–5

Hinrich, L.B., B.L. McNeal and G.A.O. Connor, 1985. *Soil Chemistry*, 2nd Ed., p. 321. Wiley–Inter Science Publication, John Wiley & Sons, Inc. USA

Keeny, D.R. and D.W. Nelson, 1982. Nitrogen Inorganic Forms. *In*: Page, A.L., M.H. Miller and D.R. Keeny (eds.), *Methods of Soil Analysis*, Part 2, 2nd Ed., pp: 643–98. American Society of Agronomy, Madison WI

Khattak, R.A. and A. Rehman. 1992. Effect of disposal of industrial wastes on the quality of Kabul River waters and soil at Pirsabak. A *final Project Report*, NWFP. Agric. Univ. TIPAN Project, Peshawar. pp: 50.

Lindsay, W.L. and W.A. Norvell, 1978. Development of DTPA soil test for Zn, Cu, Fe and Mn. *Soil Sci. Soci. Am. J*., 42: 421–8

Mclean, E.O., 1982. Soil pH and Lime Requirement. *In:* Page, A.L., M.H. Miller and D.R. Keeny (eds.), *Methods of Soil Analysis*, Part 2, 2nd Ed., Pp: 209–23. American Society of Agronomy, Madison WI

Nelson, D.W. and L.E. Sommer, 1982. Total Carbon, Organic Carbon and Organic Matter. *In*: Page, A.L. M.H. Miller and D.R. Kenny (eds.) *Methods of Soil Analysis*, Part 2, 2nd Ed., pp: 539–77. American Society of Agronomy, Madison WI, New York, USA

Rabbi, F., 1999. Biological and Chemical transformation of P in some important soil series of NWFP. *M.Sc. (Hons.) Thesis*, Department of Soil Science, NWFP Agriculture University, Peshawar–Pakistan

Rhoades, J.D., 1982. Soluble Salts. *In*: Page, A.L., M.H. Miller and D.R. Keeny (eds.) *Methods of Soil Analysis*, Part 2, 2nd Ed., pp: 167–79. American Society of Agronomy, Madison WI

Richards, L.A., 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. Hand Book 60 USDA

Russell, E.W., 1973. *Soil Conditions and Plant Growth,* p: 58. 10th Ed. Longman Group Ltd., London, UK

Steel, G.D.R. and J.H. Torrie, 1980. *Principles and Procedures of Statistics,* 2nd Ed., p. 219. McGraw Hill, Inc. New York, USA

Westerman, R.L. and T.C. Tucker 1974. Effect of salts and salts plus nitrogen. 15. Labelled ammonium chloride on mineralization of soil nitrogen, nitrification, and immobalization. *Soil Sci. Soc. Am. Proc*. 38: 602–5

(Received 10 September 2003; Accepted 28 January 2004)