IMPACT OF FLY ASH /POND ASH IN VERTISOLS ON LONG TERM BASIS VIS-À-VIS ON GRAIN YIELD OF SUNFLOWER AND MAIZE AND STATUS OF HEAVY METALS AND ACTIVITY OF RADIO NUCLIDES IN SOIL

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SUMMARY

Fly ash / pond ash has potential for bulk utilization in agriculture as a source of nutrients to plants and as a soil conditioner. The study presents the results on analysis of heavy elements and activity of naturally occurring radionuclides in irrigated vertisols in sunflower-maize cropping sequence over a period of three years (2004-06). The results on final status of heavy elements indicates that the application of either FA/PA has resulted in marginal build up of total Se, AS and Pb in soil. Its content has less in soil treated with pond ash than fly ash. The difference may be attributed to higher content of elements in fly ash than pond ash it was suggested that the content of total Se, As and Pb, in soil increased with increasing level of fly ash application without any carry over of heavy elements . The per cent difference over control was 40,53 and 7 in Se, As and Pb respectively. On the contrary ,addition of organics to either FA/PA helps to decontaminate the level of heavy elements in soil .Further ,application of FA/PA at maximum dose increased the activity of natural radionuclides in soil and the effects could be reduced with combined application of fly ash and FYM. The per cent difference over control was 47,14 and 3 in ^{226}Ra,^{228}Ac and ^{40}K, respectively.

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In India too, much increasingly R & D work is being directed in recent years on the application of fly ash in agriculture sector. Fly ash, being rich in nutrients and of pozzolanic character, offered good potential for agriculture. At College of Agriculture, Raichur, Karnataka, a systematic and in-depth studies on the utilization of fly ash in agriculture sector under various soil types and in varying agro-climatic conditions have been carried out over the past one and half decade, where it has been rather well established that fly ash can be advantageously used in agriculture as soil conditioner, source of essential plant nutrients, in improving important physico-chemical properties of the soil and boosting the crop growth and yields of a variety of crops and for reclamation of waste/degraded lands etc.

In a sequel to the studies made on long term basis (2004-06) for cultivation of sunflower and maize in irrigated vertisols in rotation, keeping the following objectives in view: (i) Safe disposal and gainful bulk utilization of fly ash/ pond ash generated from RSTPS, Shaktinagar. (iii) Study of its effect on growth and yields of various crops specific to this region including the effects on heavy metal status and activity of radionuclides of soil.

MATERIALS AND METHODS

Soil :

Field experiments were carried out on irrigated vertisol belonging to the Raichur series of Typic Haplustert. Composite soil samples collected from the experimental site before the start of experiments were analyzed for various parameters by adopting standard methods (Table 1).

The soil was clay in texture, alkaline in reaction (pH 8.6), low in soluble salt content (0.1 dS/m) and high in organic carbon, available nitrogen and potassium contents. The DTPA extractable Cu, Fe, Mn and Zn content were 1.59, 2.17, 8.13 and 0.90 mg/kg of soil, respectively. The total lead, arsenic and selenium contents were 13.9, 1.2 and 0.9 mg/kg of soil. Field experiments were conducted at Agricultural College Farm, Raichur, Karnataka from 2004 to 2006. Raichur is located in the North Eastern Dry Zone (Zone-1) of Karnataka between 16^0 15' N latitude 77^0 20' E longitudes and at an altitude of 389 meters above mean sea level (MSL).

Fly ash :

Fly ash used in the experiments during 2004 and 2006 was collected from Raichur Super Thermal power Station (RSTPS), Shaktinagar, Raichur. The ash collected from hoppers is designated as fly ash (FA) while the ash collected from settling pond is called as pond ash (PA). Thus, samples collected during 2004, 2005 and 2006 were

Table 1: Characterization of soil, FYM and fly ashes

Parameters	Vertisol	FYM			Fly ash			Pond ash		
		2004	2005	2006	2004	2005	2006	2004	2005	2006
Physical properties										
Sand (%)	9.20	-	-	-	21.50	19.80	20.50	30.20	32.81	34.20
Silt (%)	27.00	-	-	-	40.10	50.20	48.40	45.60	48.20	46.50
Clay (%)	63.80	-	-	-	38.40	30.00	31.10	24.20	18.59	19.30
Texture	C	-	-	-	SiCL	SiCL	SiCl	SiL	SiL	SiL
Porosity (%)	50.90	-	-	-	-	-	-	-	-	-
BD (Mg/m-3)	1.30	0.64	0.70	0.66	0.95	0.99	0.94	1.05	1.00	1.12
MWHC (%)	64.20	145.40	155.20	140.35	48.10	50.20	45.20	63.60	66.10	56.50
FC (%)	36.70	84.20	82.00	80.50	24.20	22.50	22.15	38.00	40.00	40.80
PWP (%)	16.40	18.50	17.30	17.90	560	5.70	5.74	11.00	12.20	12.50
Chemical properties										
pH (1:2)	8.60	7.10	7.70	7.23	10.50	9.82	9.30	9.30	8.99	8.85
EC (dS/m)	0.10	0.32	0.60	0.45	1.00	0.87	0.75	0.50	0.34	0.45
OC (%)	0.90	-	-	-	-	-	-	-	-	-
Total N (%)	0.09	1.12	1.24	1.03	0.008 ppm	0.007	0.008	0.015	0.015	0.024
Av.N (kg/ha)	306.10	310 (ppm)	355 ppm	380 (ppm)	23.60 ppm	30.25	28.45	38.80 ppm	39.60 ppm	30.50 ppm
Total P (%)	0.08	0.62	0.80	0.65	0.23 ppm	0.43	0.32 ppm	0.38	0.42	0.21
Av. P_2O_5 (kg/ha)	10.20	795 (ppm)	890 ppm	803 ppm	13.20 ppm	16.70 ppm	14.5 ppm	10.32 ppm	11.62 ppm	13.8 ppm
Total K (%)	1.65	0.93	1.10	0.98	1.42 ppm	1.80	1.36	1.10	1.60	1.50
Av. K_2O (kg/ha)	770.35	1020(ppm)	1126 ppm	1091 ppm	135.80 ppm	145.20 ppm	155.8 ppm	94.20 ppm	11.20 ppm	29.50 ppm
Total S (%)	0.06	0.26	0.36	0.29	1.70	2.50	2.24	1.40	1.75	1.65
Available (SO_4-S)	38.00	14 (ppm)	15.3 ppm	15.60 ppm	65.00 ppm	78.20 ppm	75.36 ppm	45.10 ppm	51.20 ppm	40.5 ppm
Total Ca (%)	1.30	1.10	1.00	1.20	3.64	3.36	2.92	2.52	2.66	3.80
Amo. Extr Ca (c.mol/kg)	39.70	-	-	-	16.00	19.20	16.91	9.30	10.10	14.20
Total mg (%)	0.78	0.15	0.14	0.09	1.36	1.19	1.65	1.70	1.53	1.25
Amo. Extr Mg (c.mol/kg)	12.10	-	-	-	12.00	13.40	14.25	2.00	5.00	3.80

analyzed and the data are presented in (Table 2).

The texture of fly ash resembled that of silty clay loam with higher proportion of silt sized particles (40.1 to 50.2%). The range of values for maximum water holding capacity was 48.1 to 51.5 per cent. The pH (9.70-10.5), EC (0.75-1.0 dS/m). The available N, P_2O_5 and K_2O contents varied from 23.6 to 30.3, 13.23 to 16.70 and 135.8 to 145.2 mg/kg ash respectively. The amount of DTPA extractable micronutrients did not vary much among the samples collected during different years. The total and bio available micronutrients *viz.*, Cu, Fe, Mn and Zn were marginally higher in fly ash compared to pond ash. The values for bio available (DTPA extractable) Fe, Mn, Cu and Zn were ranged from 8.66 to 13.23, 8.44 to 13.06, 0.30 to 0.62 and 1.03 to 1.52 mg/kg, respectively. The concentration of heavy

Table 2 : Content of heavy metals and radionuclide activity in soils, FYM and fly ashes

Parameters	Vertisol	FYM			Fly ash			Pond ash		
Heavy metals		2004	2005	2006	2004	2005	2006	2004	2005	2006
Total Se (ppm)	0.90	0.50	0.50	0.40	1.60	1.60	1.20	1.40	1.30	1.12
Av. Se (ppm)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total As (ppm)	1.20	0.70	0.80	0.45	2.30	2.50	3.01	1.90	1.90	1.28
Av. As (ppm)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Pb (ppm)	13.90	7.50	7.90	6.10	18.40	20.20	16.10	17.20	16.40	20.5
Av. Pb (ppm)	0.18	0.06	0.05	0.10	0.03	0.04	0.09	0.03	0.03	0.02
Radio nuclides (Bq/kg)										
Gamma 40K	282.30	145.80	136.60	122.4	359.30	363.50	281.3	353.70	342.40	3000.10
Gamma 226Ra	37.50	16.90	16.60	15.8	99.70	103.20	114.50	91.80	103.20	99.2
Gamma 228 Ac	65.90	26.30	24.40	30.1	108.20	110.30	96.50	106.20	101.70	98.5

metals such as lead, arsenic and selenium in fly ash ranged from 18.4 to 20.4 ppm, 2.3 to 2.8 ppm and 1.6 to 1.60 ppm, respectively. The total contents of (18.7) Pb, As and Se in pond ash ranged from 16.4 to 18.7 ppm, 1.90 to 2.1 ppm and 1.3 to 1.5 ppm. However, the concentration of Cd in both the ashes was below detection level. The gross α activity observed in fly ash was 236.6 Bq/kg and in pond ash 210.8 to 225.1 Bq/kg. There was not much difference in the gross β activity of both ashes. Similarly, the activities of γ emitters like ^{40}K, ^{226}Ra and ^{228}Ac were also higher in fly ash than pond ash. The variations in properties of fly ash might be attributed to the parent coal source, handling and storage of fly ash.

The pond ash represented silt loam in texture with high water holding capacity (63.6 to 68.1%). The pH ranged from 7.9 to 9.3 and EC from 0.34 to 0.50 dS/m. The contents of available nutrients in pond ash were low compared to fly ash. The total content of Pb, As and Se in pond ash was 1.72, 1.9 and 1.4 ppm, respectively. The DTPA extractable micronutrients such as Cu, Fe, Mn and Zn were 0.36, 10.56, 10.23 and 1.29 mg/kg, respectively. The radionucleides *viz.*, α β and γ (^{40}K, ^{226}Ra and ^{228}AC) were 225, 616.8, 342.4, 91.80 and 106.0 Bq/kg, respectively.

FYM :

The samples collected during 2004-06 were analyzed separately for various parameters. The FYM was neutral in reaction (pH 7.1 to 7.7), low in EC (0.32 to 0.60 dS/M) and rich in available nutrients (Table 2). The available N, P_2O_5 and K_2O contents varied from 310 to 355, 795 to 890 and 1020 to 1126 mg/kg, respectively. The total content of Pb, As and Se in FYM was 7.50, 0.70 and 0.50 mg/kg, respectively. The activity of radionuclides *viz.*, a, b and g (^{40}K,^{226}Ra and ^{228}AC) were 119.9, 153.1, 145.8, 16.8 and 26.3 Bq/kg, respectively. The required quantities of fly ash/pond ash were applied to each plot and spread uniformly on the surface and mixed into the soil by tractor ploughing and harrowing about a month before sowing.

RESULTS AND DISCUSSION

Characterization of fly ash, pond ash, soil and FYM:

The black soil represents Raichur series (Typic haplustert). The soil is clay in texture, alkaline in reaction, low in soluble salt and high in water holding capacity. The texture of dry fly ash represented silty clay loam with 40 per cent silt sized particles. It was highly alkaline in reaction, low in soluble salt content and water holding capacity. The texture of pond ash was silt loam with higher proportion of silt sized particles. It was alkaline in reaction, low in soluble salt but high in water holding capacity. The black soil, in general, had no constraints for crop production. Fly ash as compared to pond ash was more alkaline and had less water holding capacity, which made it inferior to pond ash for agriculture utilization. The pH of the farmyard manure (FYM) used in the study varied between 7.1 and 7.7, while the EC value from 0.3 and 0.6 dS/m and water holding capacity from 141.2 and 155.2 per cent. Similar results were also reported by Chang *et al.* (1977), Hussian Saheb (1993) and Adriano *et al.* (1980). A comparison between the physical characteristics of both the dry FA and PA and soil (Table 1) showed that (i) the vertisol and both the ashes were alkaline, (ii) BD of both the ashes were lower, while WHC and porosity were higher than the soil, (iii) silt content of both the ashes was higher than the soil.

Effect of fly ash/pond ash on crop yield :

The data furnished in Table 3 revealed that during *kharif 2004*, the seed yield of sunflower in control was 5.2 q/ha, which has increased significantly due to application of either fly ash or pond ash. The maximum seed yield of 9.3 and 9.2 q/ha were recorded in T_3 and T_7 treatments, respectively. The per cent increase in yield over control was 78.4 and 76.9, respectively. During *kharif* 2005, the seed yield of sunflower in control was 9.6 q/ha, which increased significantly due to application of either fly ash or pond ash. The maximum seed yield of 13.6 and 13.5 q/ha was obtained in T_3 and T_7 treatments, respectively, which accounted to 41.7 and 40.6 per cent increase in yield over control, respectively . During *kharif* 2006 also, the seed yield of sunflower varied from 6.7 q/ha in control to a maximum of 10.2 q/ha in both T_3 and T_7 treatments with an increase of 52.2 per cent over control. Lobl *et al.* (1971) reported increased seed yield of sunflower in red/black soil which was attributed to increase in soil moisture holding capacity, friability indices and increased nutrient availability.

During *rabi* 2004, the yield of maize in control was 14.8 q/ha, which increased significantly due to application of either fly ash or pond ash. The maximum grain yield of 21.9 and 20.6 q/ha was recorded in T_3 treatment followed by T_7 treatment. The increase in yield over control was 48.0 and 39.2 per cent, respectively. During *rabi* 2005, the grain yield recorded in control was 18.7 q/ha. Application of either fly ash or pond ash increased the grain yield significantly. The maximum grain yield recorded was in T_7 treatment which accounted for 36.4 per cent

Table 3 : Effect of fly ash levels on grain yield of crops in irrigated vertisols

Treatment/cropping season & name of the crop	Critical difference (@ 5 %)	T_1 (control) Treatment Mean ***	T_2: RDF + FA @ 30t/ha every year			T_3: T_2+ FYM @ 20t/ha every year			T_4: RDF + FA @40t/ha every year			T_5: RDF + FA 40t/ha once in three years		
			Tr. Mean*** (q/ha)	% diff. over control	Sig. Diff. over control	Tr. Mean** * (q/ha)	% diff. over control	Sig. Diff. over control	Tr. Mean** * (q/ha)	% diff. over control	Sig. Diff. over control	Tr. Mean** * (q/ha)	% diff. over control	Sig. Diff. over control
kharif 2004 sunflower	0.77	5.2	8.3	6.0	*	9.2	76.9	*	8.7	67.3	*	8.4	61.5	*
rabi 2004 – 05 maize	3.28	14.8	18.4	24.3	*	21.9	48.0	*	20.0	35.1	*	19.0	28.4	*
kharif 2005 sunflower	1.14	9.6	11.8	22.9	*	13.6	41.7	*	13.0	35.4	*	11.7	21.9	*
rabi 2005-06 maize	2.26	18.7	23.0	23.0	*	24.0	28.3	*	22.1	18.2	*	22.0	17.6	*
kharif 2006 sunflower	1.82	6.7	8.0	19.4	NS	10.2	52.2	*	8.4	25.4	NS	8.7	29.9	*
rabi 2006-07 maize	0.74	17.4	19.4	12.1	*	25.9	49.0	*	20.2	16.2	*	17.7	1.8	NS
Pooled	1.82	14.3	18.0	26.0	*	21.0	47.1	*	19.4	31.3	*	17.8	27.3	*

Treatment/cropping season & name of the crop	Critical difference (@ 5 %)	T_1 (control) Treatment Mean ***	T_2			T_3			T_4			T_5		
			Tr. Mean*** (q/ha)	% diff. over control	Sig. Diff. over control	Tr. Mean** * (q/ha)	% diff. over control	Sig. Diff. over control	Tr. Mean** * (q/ha)	% diff. over control	Sig. Diff. over control	Tr. Mean** * (q/ha)	% diff. over control	Sig. Diff. over control
kharif 2004 sunflower	0.77	5.2	9.10	75.0	*	9.3	78.4	*	8.1	55.8	*	9.0	73.1	*
rabi 2004 – 05 maize	3.28	14.8	19.20	29.7	*	20.6	39.2	*	19.5	31.8	*	20.1	35.8	*
kharif 2005 sunflower	1.14	9.6	12.50	30.2	*	13.5	40.6	*	11.5	19.8	*	11.7	21.7	*
rabi 2005-06 maize	2.26	18.7	23.2	24.1	*	25.5	36.4	*	24.3	29.9	*	21.4	14.4	*
kharif 2006 sunflower	1.82	6.7	8.2	22.9	NS	10.2	52.2	*	8.2	22.4	NS	7.1	8.0	NS
rabi 2006-07 maize	0.74	17.4	22.0	26.6	*	27.8	60.4	*	20.4	17.6	*	17.5	1.0	NS
Pooled	1.82	14.3	18.9	32.3	*	21.3	49.2	*	18.3	30.6	*	17.5	25.0	*

* Significance of values at P=0.05, NS: Non significant, *** Mean of three replications

increase in yield over control. During *rabi* 2006, the grain yield of maize in control was 17.4 q/ha which increased significantly to a maximum of 27.8 q/ha in T_7 treatment. The per cent increase in yield was 60.35 per cent over control. Similarly, T_3 recorded the grain yield of 25.85 q / ha with 48.9 per cent increase over control. Similar observations were also been made by (Plank *et al*.,1975 and Sajwan *et al*.,1996).

In cropping system, the grain yield of crops in control was 14.3 q/ha. Application of different levels of either fly ash or pond ash increased the grain yield significantly. The maximum grain yield of 21.34 q/ha was observed in T_7 treatment. The per cent increased in grain yield over control due to T_7 and T_3 treatments was 49.2 and 47.1 respectively than other treatments receiving either fly ash or pond ash were *at par*.

The pooled analysis for the cropping system has been worked out by taking the concept of equivalent yield considering the prevailing market price of commodities at harvest. The maize yield was converted to sunflower yield by multiplying by the factor 0.42. The pooled data for the cropping system indicated that the total yield of edible product in control was 14.3 q/ha which increase significantly due to application of flies ash. The highest yield of 21.34 q/ha was recorded in T_7 followed by T_3 (21.04 q/ha) treatment. The increase in yield over control was 49.23 and 47.13 per cent, respectively.

Application of either pond ash or fly ash increased the grain yield of both sunflower and maize crops significantly. However, application of ash in conjunction with FYM produced the maximum yield. There was no significant difference between fly ash and pond ash treatments.

Effect of fly ash and pond ash on final status of total heavy metal concentration in soil :

The data presented in Table 4 revealed that the total content of Se, As and Pb in control increased slightly from the initial level of 0.9, 1.2 and 13.9 mg kg^{-1} soil, respectively to 1.0, 1.3 and 14.0 mg kg^{-1} soil at the end of 3 years. The total content of Se, As and Pb in T_4 treatment receiving fly ash @ 40 t/ha^{-1} was 1.4, 2.0 and 15.5 mg kg^{-1} soil, respectively. While in the treatment receiving fly ash @ 30 t/ha along with FYM @ 20 t/ha, it was 1.2, 1.8 and 14.8 mg kg^{-1} soil, respectively. Similar trend was observed with pond ash. The per cent increase in the content of these heavy metals was less in treatments receiving either fly ash or pond ash @ 30 t/ha along with FYM @ 20 t/ha when compared to treatment receiving either fly ash or pond ash @ 40 t/ha. Application of either fly ash or pond ash has resulted in marginal build-up of total Se, As and Pb in soil. Its content was less in soil treated with pond ash than with fly ash. The difference may be attributed to higher content of these toxic elements in fly ash than pond ash. The data only suggested that the content of total Se, As and Pb in soil increased with increasing level of fly ash application. On the contrary, addition of organics to either fly ash/pond ash may help to decontaminate the level of toxic elements in soils.

application of fly ash/pond ash with FYM helped in lowering the toxicity of heavy metals in soils. Similar results were also noticed by (Vijayan and Das 1998 and Sims *et al.,* 1995).

Effect of fly ash and pond ash on the final status of radionuclides in soil :

The initial level of radionuclides such as ^{226}Ra, ^{228}Ac and ^{40}K in soil were 37.5, 65.9 and 288.3 Bq/kg. Application of fly ash/pond ash at maximum dose increased the activity of natural radionuclides in the soil. It was due to direct addition of natural radionuclides into soil by the ashes. This effect could be reduced with the combined application fly ash/pond ash and FYM. The results are in agreement with (Kolke, 1979 and Mishra and Sadashivan, 1982).

The data presented in Table 5 revealed that the activity of ^{228}Ac and ^{40}K in the initial soil was 65.9 and 288.3 Bq/kg soil, respectively, which, decreased to 63.4 and 277.9 Bq/kg, respectively due to cultivation of sunflower – maize crops in sequence continuously for 3 years with recommended dose of fertilizer NPK dose only. The results are in consonance with the findings of (Ghodrati *et al*., 1995). The activity of ^{226}Ra, ^{228}Ac and ^{40}K radio nuclides in soil increased due to

Table 4 : Effect of fly ash / Pond ash levels on final status of total heavy metal content (mg/kg) in irrigated vertisols

Material/elements	Selenium		Arsenic		Lead	
Total content in fly ash	1.63		22.53		19.66	
Total content in pond ash	1.40		1.96		17.40	
Total content in soil (initial) control	0.90		1.20		13.90	
Total content in soil (Final) control	1.00		1.10		13.90	
Treatments	Treatment mean	% difference over control	Treatment mean	% difference over control	Treatment mean	% difference over control
T_4 – Maximum dose fly ash	1.40	40.00	2.00	53.84	15.50	11.50
T_3 – Maximum yield using fly ash	1.20	20.00	1.80	38.46	14.80	5.71
T_8 – Maximum dose pond ash	1.40	40.00	2.20	53.84	16.90	20.71
T_7 – Maximum yield using pond ash	1.20	20.00	1.60	23.07	14.90	6.42

Effect on final status of total heavy metals in soils :

The initial level of heavy metals in soil was (0.9 ppm Se,1.2 ppm As and 13.9 ppm Pb). Application of fly ash/ pond ash at maximum dose marginally increased the content of heavy metals in the soil (Table 4). Since both fly ash and pond ash are the potential sources of heavy metals, application of which might possibly increase the level of heavy metals in soil. Similarly, combined application of fly ash/pond ash @ 40/30 t/ha with FYM @ 20 t/ha also increased the total content of these heavy metals in both the soils, but it was less than that observed with maximum dose of fly ash/pond ash. The combined application of fly ash at maximum dose. Similar effect was noticed with the application of pond ash. The activity of ^{40}K was comparable with that of control soil in all the treatments. However, combined application of pond ash with FYM increased the activity of radionuclides in soil considerably as compared to other treatments. The extent of increase in the activity of ^{226}Ra, ^{225}Ac and ^{40}K in T_7 treatment over control was 26.76, 14.35 and 7.52 per cent, respectively. The corresponding per cent increase in T_3 treatment was 12.12, 18.76 and 1.04 per cent. The activity of ^{226}Ra, ^{228}Ac and ^{40}K in fly ash was 91.8,106.0 and 350.7 Bq/

Table 5 : Effect of fly ash / pond ash levels on the activity of radio nuclides (Bq/kg) in soil at the end of the experiment in irrigated vertisol

Material/elements	^{226}Ra		^{228}Ac`		^{40}K	
Total content in fly ash	91.80		106.00		353.70	
Total content in pond ash	99.70		108.20		359.30	
Total content in soil (initial) control	37.50		65.90		288.20	
Total content in soil (Final) control	39.60		63.40		277.90	
Treatments	Treatment mean	% difference over control	Treatment mean	% difference over control	Treatment mean	% difference over control
T_4 – Maximum dose fly ash	48.10	21.46	70.50	11.19	288.20	3.70
T_3 – Maximum yield using fly ash	44.40	12.12	75.30	18.76	280.80	1.04
T_8 – Maximum dose pond ash	47.90	20.95	69.80	16.09	284.30	2.30
T_7 – Maximum yield using pond ash	50.20	26.76	72.80	14.35	298.80	17.52

kg ash, respectively and it was comparable with pond ash (^{226}Ra 97.7Bq/kg, ^{228}Ac 108.2 Bq/kg and ^{40}K359.2 Bq/kg). The initial level of radio nuclides such as ^{226}Ra, ^{228}Ac and ^{40}K in black soil were 37.5,65.9 and 288.3 Bq/kg ash. Application of fly ash / pond ash at maximum dose increased the activity of natural radionuclide in soil. It was due to direct addition of natural radionuclide into soil by the ashes. This effect could be reduced with the combined application of either fly ash / pond ash and FYM.

In view of the above, it can be inferred that utilization of fly ash in agriculture is a very potential area in which bulk utilization of fly ash is most likely. However, there is still the need for the long-term studies to be continued especially in respect of apprehended hazardous effects, if any, due to trace elements and heavy metals as also radioactivity to fully dispel such apprehensions. It is observed that the effect of FA and PA at maximum dose of treatment on the final status of total trace and heavy metals such as Pb, Se, and As in soil is either increased or decreased slightly on application of these ashes. As soil itself contains some of these trace and heavy metals which may not cause any serious concern especially for the reason of this increase/decrease in reality not being very significant over control.

As far as, the radioactivity level in the soil concerned, it is observed that the effect of maximum dose/yield treatment of these ashes at the end of the trial period on the radionuclide level in soil and water evinces that the concentration of ^{226} Ra and ^{228}Ac The in fly ash / pond ash amended soil remains the same as that of control. However, the concentration of ^{40} K increased noticeably from 258.6 to 297.00 and 288.10 Bq/Kg in T_4 and T_7, respectively due to fertilizer applied and also due to fixing and enrichment of 40K ions in the soil clays, organic matter and carbonates by vermiculite and related interstratified minerals. The activity of natural radionuclides, *viz.*, ^{226}Ra, ^{228}Ac and ^{40}K in soils amended with fly ash/pond ash was comparable with that present in normal soils. Hence, it can be safely used on agricultural land.

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