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Effect of solid waste from a chlor-alkali factory on rice plant

D. Dash*, D.R. Nanda and B.B. Mishra

College of Basic Sciences and Humanities, Orissa University of Agriculture and Technology, Bhubaneswar-751003 Orissa, India

ABSTRACT

Seedlings of rice var. IR-36 when exposed to mercury contaminated waste soil from a chlor-alkali factory containing 0.95 g of mercury, 30 days after transplanting, mercury accumulation increased from 3.70 ± 0.22 mg in 2.5 per cent waste soil combination (WSC) to 11.11 ± 0.14 mg in 17.5 per cent waste soil combination WSC per g fresh weight of shoot. In root mercury accumulation increased from 9.43 ±0.38 mg g^{-1} in 2.5 percent WSC to 24.26 + 0.26 mg g^{-1} fresh weight in 17.5 per cent WSC. The accumulation depended both on soil contamination and time. The root length and shoot length decreased with increase in waste soil contamination. The content of chlorophyll, nucleic acid and protein decreased with increasing soil contamination and time. The percentage decrease of root length is 57.02, shoot length is 52.60,Chl-a is 62.00,chl-b is 62.12, total chl is 61.70,carotenoid is 67.34, DNA is 68.61, RNA is 63.15 and that of protein is 77.29.Changes in these variables were significantly correlated with waste soil combination and mercury uptake.

Key words: *Solid waste, chlor-alkali factory, mercury, rice plant*

Heavy metal pollution is a serious problem in many rice growing regions of the world. Among the heavy metals mercury plays an important role in decreasing the productivity of many crops due to its accumulation in the plant. It also creates terrible health hazard. Major sources of mercury contamination include exhaust, effluent and solid wastes from various industries including chlor-alkali factories (Mishra, 1986; Shaw and Sahu 1987). This contamination also affects the nearby plants including crop fields (Barman and Bhargab, 1997).

M/s Jayashree Chemicals, a chlor-alkali factory in Ganjam district of Orissa, releases effluent into the river Rushikulya, exhaust air into the atmosphere through ventilators and the solid waste (soil) is dumped by the side of the effluent channel. The dump waste is subjected to aerial dispersal during summer. In monsoon, the dissolved salts, along with mercury, enter the nearby rice fields with runoff water and contaminate the soil.

Reports pertaining to the accumulation and effects of mercury in crop plants are very few. Mishra and Mishra (1984) and Nanda *et al*. (1986) reported that changes in the morphological character of crop plants are induced by the saturated solid waste extracts. Therefore, an attempt was made to determine the damaging effects of solid waste generated by a chlor-alkali factory on biochemical variables like chlorophyll, nucleic acid, protein, and free amino acid content of rice seedlings.

MATERIALS AND METHODS

The waste soil was collected in gunny bags, air dried and powdered manually for use in the experiment. The dried and powdered waste soil was passed through a fine mesh and was used for the preparation of culture pots. Varying concentrations of the waste soil ranging from 2.5 per cent to 17.5 per cent was prepared with normal garden soil (pH 6.44). Final weight of the soil combinations prepared was 4kg. They were kept in earthen pots of equal size in triplicate. The waste soil combinations and water were mixed thoroughly and allowed to settle. The level of water in all pots was marked with permanent paints and water level in the waste soil combinations was maintained daily. After the soil suspensions settled, the supernatant water was taken for determination of soil pH. A control set with only garden soil was maintained for comparison. Eight seedlings of 26 days old rice var. IR 36 grown on garden soil and compost were transplanted in each pot. The data obtained were subjected to statistical analysis like correlation coefficients and the level of significance between the waste concentration and the variables (Misra and Misra 1984).

RESULTS AND DISCUSSION

The grey coloured soil was alkaline in nature with a pH of 9.20. It contained 0.95g mercury, 6g Na, 18g Cl and 55mg K kg^{-1} of waste soil. Mercury accumulation was found to increase with increase in waste soil from 2.5 percent to 17.5 percent and also 15 days after transplant (DAT) to 30 DAT (Table 1). In the control set with only garden soil mercury accumulation was not detected at 15 DAT mercury accumulation increased form 5.10 mg g^{-1} fresh weight in 2.5 percent waste soil combination (WSC) to 14.66 mg g^{-1} fresh weight in 17.5 percent WSC. A highly significant positive correlation was obtained between waste soil and mercury uptake by root (r = + 0.992). At 30 DAT mercury accumulation increased from 9.43 mg g^{-1} in 2.5 percent WSC to 24.26 mg g^{-1} fresh weight in 17.5 per cent WSC. The positive correlation (r = + 0.992) between waste soil combinations and mercury uptake by root was highly significant.

The accumulation of mercury in shoot increased with increase in waste soil (2.5% to 17.5%) and time (15 DAT to 30 DAT). After 15 days transplantation of the rice seedlings, mercury accumulation in shoot increased from 2.45 mg g^{-1} fresh weight in 2.5 per cent WSC to 9.82 mg g^{-1} fresh weight in 17.5 per cent WSC. The correlation between mercury uptake in shoot and per cent waste soil combinations were positive and highly significant (r = +0.991) (Table 1). At 30 DAT mercury accumulation increased from 3.70 mg in 2.5 per cent WSC to 11.11 mg in 17.5 per cent WSC per g fresh weight of shoot. A highly significant positive correlation (r = + 0.996) was obtained between mercury accumulation and waste soil combination.

With increase in percentage of waste soil and time, a gradual decrease in root length and plant height was reported. Fifteen days after transplantation of the rice seedlings, root length decreased from 11.51 cm in the control (with only garden soil) to 5.01 cm in 17.5 per cent waste soil combination. Decrease in root length over control increased from 10.25 per cent in 2.25 per cent of WSC to 56.47 per cent in 17.5 per cent waste soil combinations. The negative correlations between waste soil combinations and root length (r = -0.989) was highly significant. A significant negative correlation was also obtained between change in root length and mercury uptake by root (r = -0.990) (Table 2). Thirty days after transplantation of rice seedlings root length decreased from 13.96 cm in the control set to 6.00 cm in 17.5 per cent waste soil combination. Percentage decreased in root length over control further increased over that of 15 DAT and ranged between 12.75 per cent in 2.5 per cent WSC to 57.02 per cent in 17.5 per cent WSC. The negative correlation (r = -0.988) between waste soil combinations and root length was highly significant. A highly significant negative correlation was also obtained between mercury uptake by root and root length (r = -0.982).

Fifteen days after transplantation of the rice seedlings shoot length decreased from 31.38 cm in the control set to 16.60 cm in 17.5 per cent waste soil combination. Percentage decrease in shoot length over control was 8.38 in 2.5 per cent WSC to 47.10 per cent in 17.5 per cent WSC. The negative correlations between percentage of waste soil and changes in shoot

Table 1. Mercury accumulation (µg g^{-1} fresh weight) from varying waste soil combinations by root and shoot at different time intervals

Plant tissue	Days after trans planting	Percentage of solid waste							Correlations (r)
		2.50	5.00	7.50	10.00	12.50	15.00	17.50	
Root	15	5.10 ± 0.38	7.22 ± 0.62	9.58 ± 0.48	10.55 ± 0.39	12.00 ± 0.36	13.32 ± 0.19	14.66 ± 0.25	0.992
	30	9.43 ± 0.38	11.66 ± 0.52	14.75 ± 0.43	16.21 ± 0.23	19.05 ± 0.27	22.00 ± 0.39	24.26 ± 0.26	0.991
Shoot	15	2.45 ± 0.18	3.18 ± 0.26	4.51 ± 0.41	5.66 ± 0.50	0.55 ± 8.05	0.71 ± 9.60	0.75 ± 11.11	0.998
	30	3.70 ± 0.22	4.45 ± 0.29	5.90 ± 0.40	6.95 ± 0.30	8.05 ± 0.24	9.60 ± 0.19	11.11 ± 0.14	0.996

Table 2. Changes in root and shoot length (in cm) of rice seedlings in varying percentage of waste soil combinations

		Percentage of solid waste									
	Days	0	2.50	5.00	7.50	10.00	12.50	15.00	17.50	Correlation (r)	
Root	15	11.51±0.15	10.33±0.20 (10.25)	9.41±0.18 (18.24)	8.39±0.15 (27.10)	7.22±0.11 (37.27)	6.48±0.15 (43.70)	6.05±0.10 (47.43)	5.01±0.08 (56.47)	a b	-0.989 -0.990
	30	13.96±0.31	12.18±0.22 (12.75)	11.06±0.15 (20.77)	9.75±0.11 (30.15)	8.24±0.22 (40.97)	7.22±0.13 (48.25)	6.17±0.15 (56.80)	6.00±0.10 (57.02)	a b	-0.992 -0.970
Shoot	15	31.38±1.00	28.75± 0.92 (8.38)	26.66±0.62 (15.04)	24.00±0.29 (23.51)	21.05±0.40 (32.91)	19.11±0.45 (39.10)	18.16±0.30 (42.12)	16.60±0.22 (47-10)	a b	-0.988 -0.982
	30	42.60± 1.23	37.68±1.00 (11.54)	34.79±0.78 (18.33)	31.20±0.85 (26.76)	26.61±0.67 (37.53)	23.84±0.60 (44.03)	22.31±0.54 (47.62)	22.19±0.45 (52.60)	a b	-0.990 -0.975

Values are mean of 3 samples ± standard deviation; Figures in parentheses indicate percentage decrease over respective control; a- versus concentration b- versus mercury uptake

length was highly significant (r = 0.992). A highly significant negative correlation was also obtained between mercury uptake by shoot and change in shoot length (r =-0.970). At 30 DAT shoot length of rice seedlings decreased from 42.60 cm in the control set to 20.19 in 17.5 per cent WSC. Percentage decrease over control was 11.54 per cent in 2.5 per cent WSC and 52.60 per cent in 17.5 per cent WSC. The negative correlation (r = -0.990) between percentage of waste soil combinations and change in shoot length was highly significant. Also, a highly significant ($P < 0.001$) negative correlation was obtained between mercury uptake by shoot and change in its length (r = -0.975) (Table 2).

As percentage of waste soil increased, a gradual decrease in chlorophyll content was observed. The decrease was further enhanced with increase in time period (Table 3). After 15 DAT chlorophyll content decreased from 1.68 mg g^{-1} fresh weight in the control set to 0.71 mg g^{-1} fresh weight in 17.5 per cent WSC. The negative correlation (r =-0.9775) between waste soil combinations and chlorophyll 'a' content was highly significant. A highly significant negative correlation (r = -0.985) was also obtained between mercury uptake by shoot and chlorophyll 'a' content (Table 3). Percentage decrease in chlorophyll 'a' content over control increased form 14.80 per cent in 2.5 per cent WSC to 57.73 per cent in 17.5 per cent WSC. At 30 DAT, chlorophyll 'a' content decreased from 2.00 mg g^{-1} in the control set to 0.76 in 17.5 per cent waste soil combinations and percentage decrease over control increased form 21.5 per cent in 2.5 per cent to 62.0 per cent in 17.5 per cent WSC. A highly significant negative correlation (r = -0.969) was obtained between waste soil combinations and change in chlorophyll 'a' content. The negative correlation (r = - 0.981) between mercury uptake by shoot and change in chlorophyll 'a' content was also highly significant.

Chlorophyll b decreased with increase in percentage of waste soil and time period (Table 4). Fifteen days after transplantation of the rice seedlings chlorophyll 'b' content from 0.58 mg g^{-1} in the control to 0.22 mg g^{-1} fresh weights in 17.5 per cent WSC. Percentage decrease over control increased from 18.96

Table 3. Changes in chlorophyll 'a' content (mg g^{-1} fresh weight) of rice seedlings following its transplantation in varying waste soil combinations at different time intervals and correlation coefficient value for Chlorophyll 'a'

	Percentage Waste Soil Combination								Corr. r value	
Days	0	2.5	5.00	7.50	10.00	12.50	15.00	17.50		
15	1.68 ± 0.10	1.43 ± 0.07 (14.80)	1.33 ± 0.08 (20.83)	1.18 ± 0.06 (29.76)	1.01 ± 0.10 (39.88)	0.90 ± 0.05 (42.42)	0.82 ± 0.04 (51.19)	0.71±0.05 (57.73)	a b	-0.975 -0.985
30	2.00 ± 0.11	1.57 ± 0.05 (21.50)	1.40 ± 0.06 (30.00)	1.26 ± 0.04 (37.00)	1.13 ± 0.08 (43.50)	0.96 ± 0.05 (52.00)	0.88 ± 0.07 (56.00)	0.76 ± 0.03 (62.00)	a b	-0.969 -0.981

Values are mean of 3 samples ± standard deviation; Figure in parentheses indicates percentage decrease over respective control; a- versus concentration b- versus mercury uptake per cent in 2.5 per cent WSC to 62.06 per cent in 17.5 per cent WSC. The negative correlations (r = 0.985 and – 0.982) between chlorophyll 'b' content and percentage waste soil combinations and mercury uptake were highly significant. At 30 DAT chlorophyll 'b' content decreased form 0.66 mg g^{-1} fresh weights in the control to 0.25 to 17.5 per cent WSC. Percentage decrease over control increased form 19.69 per cent in 2.5 per cent WSC to 61.12 per cent in 17.5 per cent WSC. The negative correlation (r = -0.959 and -0.976) of chlorophyll 'b' content with percentage waste soil and mercury uptake by shoot was highly significant.

With increase in waste soil combinations, and time period, a decrease in total chlorophyll content was reported (Table 5). Fifteen days after transplantation of the rice seedlings, total chlorophyll content decreased from 2.60 mg g^{-1} fresh weight in the control plant to 1.20 mg g^{-1} fresh weight in 17.5 per cent WSC with an increase in per cent decrease over control from 9.61 per cent in 2.5 per cent WSC to 53.04 per cent in 17.5 per cent WSC. The negative correlations of total chlorophyll content with percentage of waste soil and mercury uptake were highly significant (r = -0.982) (Table 5). After 30 days of transplantation of the rice seedlings, total chlorophyll content decreased from 3.16 mg g^{-1} fresh weight to 1.21 mg g^{-1} fresh weight from the control set to 17.5 per cent waste soil combinations. Percentage decrease over control increased form 20.56 per cent in 2.5 per cent WSC to 60.70 per cent in 17.5 per cent WSC.

With increase in percentage of the waste soil and time, a gradual decrease in carotenoids content was found **(**Table 6). After 15 DAT carotenoids content decreased from 0.25 mg g^{-1} fresh weights in control to 0.08 mg g^{-1} fresh weight of shoot in 17.5 per cent WSC. Percentage decrease over control increased from 12.00 per cent in 2.5 per cent waste soil to 68.00 per cent in 17.5 per cent WSC combinations. The negative correlations (r = 0.984 and -0.980) of carotenoids content between WSC and mercury were shighly significant. Thirty days after transplantation of the rice seedlings, carotenoids content decreased form 0.49 mg g^{-1} fresh weight in control to 0.16 mg g^{-1} fresh weights to 17.5 per cent WSC. Percentage decrease over control increased from 30.61 per cent in 2.5 per cent WSC to 63.34 per cent in 17.5 per cent of waste soil combinations. The negative correlation (r = -0.957 and -0.978) of carotenoids content with waste soil combinations and mercury uptake were significant (Table 6).

DNA content decreased with increase in waste soil combinations and time period of exposure (Table7). After 15 DAT, DNA content of shoot decreased from 1.05 mg g^{-1} fresh weight to 0.39 mg g^{-1} fresh weight. The percentage decrease over control increased from 20 percent in 2.5 per cent WSC to 62.85 per cent in 17.5 percent WSC. The negative correlations (r=-0.977 and -0.979) of DNA content with waste soil combinations and mercury uptake were highly significant (Table 7). Again 30 days after transplantation, DNA content decreased from 2.39 mg g^{-1} in control set to 0.75 mg g^{-1} fresh weight in 17.5 percent waste soil combinations with percentage decrease of 26.77 in 2.5 percent waste soil to 68.61 percent in 17.5 percent WSC. The negative correlations (r = -0.963 and -0.984) of DNA content with waste soil combinations and mercury uptake respectively were highly significant.

RNA content decreased with increase in waste soil combinations from 2.5 percent WSC to 17.5 percent WSC and time period of exposure from 15 days to 30 days (Table 8). After 15 days of transplantation, RNA content of shoot decreased from 0.85 mg g^{-1} fresh

Table 4. Changes in chlorophyll 'b' content (mg g^{-1} fresh weight) of rice seedlings following its transplantation in varying waste soil combinations at different time intervals

Days	% Waste soil Combinations									Corr.r value
	0	2.5	5.00	7.50	10.00	12.50	15.00	17.50		
15	0.58± 0.05	0.47±0.03 (18.96)	0.45± 0.02 (22.41)	0.39± 0.01 (32.75)	0.35± 0.01 (39.05)	0.30± 0.03 (48.27)	0.28± 0.04 (51.72)	0.22± 0.05 (62.06)	a b	-0.985 -0.982
30	0.66± 0.08	0.53± 0.04 (19.69)	0.44± 0.03 (33.33)	0.40± 0.02 (39.39)	0.36± 0.04 (45.45)	0.32± 0.03 (51.51)	0.30± 0.05 (54.54)	0.25± 0.03 (61.12)	a b	-0.959 -0.976

Values are mean of 3 samples ± standard deviation; Figure in parentheses indicates percentage decrease over respective control; a- versus concentration b- versus mercury uptake

Table 5. Changes in total chlorophyll content (mg g^{-1} fresh weight) of rice seedlings in varying waste soil combination for different time periods

Days	Percentage Waste Soil Combinations								Corr. r value	
	0	2.5	5.00	7.50	10.00	12.50	15.00	17.50		
15	2.60± 0.15	2.35± 0.09	2.16± 0.08	1.88± 0.06	1.70± 0.08	1.49± 0.09	1.38± 0.05	1.20± 0.03	a	-0.995
		(9.61)	(16.92)	(27.69)	(34.61)	(42.69)	(46.92)	(53.04)	b	-0.982
30	3.16± 0.13	2.51± 0.07	2.21± 0.06	2.03± 0.20	1.82± 0.08	1.58± 0.09	1.40± 0.04	1.21± 0.05	a	-0.974
		(20.56)	(30.06)	(35.75)	(42.40)	(50.00)	(55.69)	(61.70)	b	-0.988

Values are mean of 3 samples ± standard deviation; Figure in parentheses indicates percentage decrease over respective control; a- versus concentration b- versus mercury uptake

Table 6. Changes in total carotenoids content (mg g^{-1} fresh weight) of rice seedlings following its transplantation in varying waste soil combinations of different time periods

Days	Percentage Waste Soil Combinations								Corr. r value	
	0	2.5	5.00	7.50	10.00	12.50	15.00	17.50		
15	0.25± 0.03	0.22± 0.02	0.18± 0.02	0.15± 0.03	0.14± 0.02	0.12± 0.02	0.11± 0.03	0.08± 0.01	a	-0.984
		(12.00)	(28.00)	(40.00)	(44.00)	(52.00)	(56.00)	(68.00)	b	-0.980
30	0.49± 0.03	0.34± 0.04	0.30± 0.05	0.26± 0.03	0.25± 0.02	0.20± 0.04	0.18± 0.05	0.16± 0.01	a	-0.957
		(30.61)	(38.77)	(46.93)	(48.97)	(59.18)	(63.26)	(67.34)	b	-0.978

Values are mean of 3 samples ± standard deviation; Figure in parentheses indicates percentage decrease over respective control; a- versus concentration b- versus mercury uptake

weight to 0.35 mg g^{-1} fresh weight. The percentage decrease over control increased from 20.00 percent in 2.5 per cent WSC to 58.82 per cent in 17.5 percent waste soil combinations. The negative correlations (r=-0.975 and -0.975) of RNA content with waste soil combinations and mercury uptake were highly significant (Table 8). Again 30 days after transplantation, RNA content decreased from 1.90 mg g^{-1} in the control set to 0.70 mg g^{-1} fresh weight in 17.5 percent waste soil combinations with the percentage decrease of 24.21 in 2.5 percent WSC to 63.15 percent in 17.5 percent waste soil combinations. The negative correlations (r =-0.959 and -0.978) of RNA content with waste soil combinations and mercury uptake were highly significant.

Protein content decreased with increase in waste soil combinations from 2.5 percent to 17.5 percent and time period of exposure from 15 days to 30 days (Table 9). After 15 days of transplanting period, protein content of shoot decreased from 8.55 mg g^{-1} fresh weight to 3.30 mg g^{-1} fresh weight. The percentage decrease over control increased from 19.29 percent in 2.5 per cent WSC to 61.40 per cent in 17.5 percent waste soil combinations. The negative correlations(r=-0.970 and -0.965) of protein content with waste soil combinations and mercury uptake were highly significant (Table 9). Again 30 days after transplantation protein content decreased from 15.90 mg g^{-1} in the control to 5.61 mg g^{-1} fresh weight in 17.5 percent waste soil combination with percentage decrease of 26.35 in 2.5 per cent WSC to 77.29 per cent in 17.5 per cent WSC. The negative correlations (r = -0.947 and -0.974) of RNA content with waste soil combinations and mercury uptake respectively were highly significant.

Roger (1976) reported methylation of divalent mercury in agricultural soil and the degree of methylation was directly proportional to the concentration of mercury in the soil and to exposure time. The experiment shows that the accumulation of mercury by the rice seedlings is dependant on both time and waste soil concentration.

The metal ions could check the formation of chloroplast, hence decline in chlorophyll content might be attributed to the toxic effect of metal generated through oxidative stress (Chaudhury and Chandra 2005).The decrease in nucleic acid content with increasing waste soil concentration and time is supported by the denaturation of double-helical DNA structure that results from treatment with mercuric acetate (Takaeuchi and Maeda, 1976).The decrease in the RNA and concentration dependant decrease in the protein content revealed a depletion induced content

Table 7. Changes in DNA content (mg g^{-1} fresh weight) at different time intervals after its transplantation in varying waste soil combinations

Days	Percentage Waste Soil Combinations								
	0	2.5	5.00	7.50	10.00	12.50	15.00	17.50	
15	1.05 ±0.07	0.84 ±0.05 (20.00)	0.75±0.09 (28.57)	0.64 ±0.05 (39.04)	0.56 ±0.06 (46.66)	0.50 ±0.08 (52.38)	0.43 ±0.04 (59.04)	0.39±0.03 (62.85)	a -0.977 b -0.979
30	2.39 ± 0.20	1.75 ± 0.15 (26.77)	1.55 ± 0.24 (35.14)	1.39 ± 0.18 (41.84)	1.22 ± 0.12 (48.95)	1.01 ± 0.13 (57.74)	0.90 ± 0.14 (62.34)	0.75 ± 0.06 (68.61)	a -0.963 b -0.984

Values are mean of 3 samples ± standard deviation; Figure in parentheses indicates percentage decrease over respective control; a- versus concentration b- versus mercury uptake

Table 8. Changes in RNA content (mg g^{-1} fresh weight) of fresh seedling at different time intervals after its transportation in varying waste soil combinations

Days	Percentage Waste Soil Combinations								Corr. r value
	0	2.5	5.00	7.50	10.00	12.50	15.00	17.50	
15	0.85 ± 0.09	0.68 ± 0.06 (20.00)	0.61 ± 0.08 (28.23)	0.55 ± 0.06 (35.29)	0.49 ± 0.07 (-42.35)	0.44 ± 0.09 (48.23)	0.39 ± 0.05 (54.11)	0.35 ± 0.02 (58.82)	a -0.975 b -0.975
30	1.90 ± 0.11	1.44 ± 0.10 (24.21)	1.30 ± 0.15 (31.57)	1.16 ± 0.11 (38.94)	1.05 ± 0.18 (44.73)	0.88 ± 0.10 (53.68)	0.83 ± 0.08 (56.31)	0.70 ± 0.06 (63.15)	a -0.959 b -0.978

Values are mean of 3 samples ± standard deviation; Figure in parentheses indicates percentage decrease over respective control.

Table 9. Changes in Protein content (mg g^{-1} fresh weight) of rice seedlings at different time intervals after its transportation in varying waste soil combinations

Days	Percentage Waste Soil Combinations								Corr. r value
	0	2.5	5.00	7.50	10.00	12.50	15.00	17.50	
15	8.55 ± 0.80	6.00 ± 0.79 (19.29)	5.27 ± 0.95 (29.82)	4.66 ± 0.65 (38.36)	4.10 ± 0.59 (45.49)	3.71 ± 0.50 (52.04)	3.30 ± 0.30 (56.60)	6.90 ± 0.71 (61.40)	a -0.970 b -0.965
30	15.90 ± 1.21	11.71± 0.99 (26.35)	10.20±0.95 (35.84)	9.03 ±0.86 (43.20)	8.11±0.60 (48.99)	6.88 ± 0.46 (56.72)	6.40 ± 0.80 (59.74)	5.61 ± 0.60 (77.29)	a -0.947 b -0.974

Values are mean of 3 samples ± standard deviation; Figure in parentheses indicates percentage decrease over respective control; a- versus concentration b- versus mercury uptake

of cyanobacteria which occurs during the reclamation of mercury contaminated waste soil (Mishra, 1986). The decrease in nucleic acid content reflects a possible interaction between pollutants of waste soil and rice seedlings (Bruin, 1976). Dash (2002) reported a similar depletion of protein induced in the *Sesbania* plant due to mercury. Thus, it is evident that the solid discharges of chlor-alkali factory, which is contaminated with high amount of mercury is toxic to the rice plants. So the accumulation of mercury in rice is a threat to the different trophic levels of the ecosystem.

REFERENCES

Barman SC and Bhargava SK 1997. Accumulation of heavy metals in soil and plants in Industrially polluted fields. Ecological issues and environmental impact assessment. Gulf publishing company, Texas.289-314

Bruin A 1976. Bio-chemical toxicity of Environmental Agents. Elsevier Publication, The Netherlands.

Chaudhury MP and Chandra R 2005. Toxicity assessment of heavy metals with Nostoc muscorum L.J.Environ . Biol.26(1):129-134

Dash D 2002. A study on interaction between Sesbania aculeata Pers & Mercury contaminated waste soil from a chlor-alkali factory. Ph.D thesis, Utkal University. India.

Mishra BB 1986. Reclamation with Blue-green algae; Changes in free-amino acid content of algae exposed to solid waste of a clor-alkali factory, Microbios Letter 33:139-142

Mishra BN and Mishra MK 1984. Introductory practical Biostatics, Naya Prakash Publisher, Calcutta India.

Mishra SR and Mishra BN 1984. Studies on the solid waste extract from a Chlor-alkali factory : I, Morphological behavior of rice seedling grown in the waste extract, Environ. Pollut 35:17-28

Nanda DR, Mishra BB and Mishra BN 1986. Changes in germination and morphological variables of a crop plant exposed to industrial waste extract, Mendel 3(3) ; 183-187

Rogers RD 1976. Methylation of mercury in agricultural soils, J Env. Poll. Qual. 5(4):454-458

Shaw BP, Sahu AK 1987. Selectivity in mercury-cupper and mercury iron accumulation in plants Water, air & soil pollution. 8:258-291

Takeuchi S and Maeda A 1976. Interaction of fluorescent reagent, Fluorescein mercuric acetate with nucleic acid, Biochem. Biophysis Acta.454(2):309-318