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Use of Agrochemical Fertilizers and Their Impact on Soil, Water and Human Health in the Khamargao Village of Mymensimgh District, Bangladesh

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Abstract: Agrochemical pollution level in soil and water were determined and their impacts on human health were identified with questionnaire survey from in the Khamargao Village of Chandipasha Union under Nandail Thana of Mymensingh District in Bangladesh. Pollution of soils and water were determined by the chemical analysis in the laboratory and the health impact by questionnaire survey. It was observed that the pollution in surface and sub surface water were found to be higher. There was no pollution in deep tube well water in the investigation area. Agro-chemical contamination in the surface water of Khamargao village was high. Human health were severally affected by the application of agro chemicals in the study area. The worst victims by agrochemicals were the applicator farmers who apply those chemicals in their field. It also been found that the old people were the most suffered age group by the agro chemical pollution.

Key words: Agrochemical pollution, impact, Mymensingh, Bangladesh

INTRODUCTION

Bangladesh one of the ancient gene center is an agrarian based less developed country of the world. She has only 0.31% of the total agricultural land in the world, but 2% of total population of the globe[1]. The per capita arable land in the country is very low and its food deficiency about 20 million tones every year. In such a situation Bangladesh needs to apply agro-chemicals and has been applying an increasing quantity of chemical fertilizers and pesticides to produce more food. The use of chemical fertilizers has increased about seven folds from 1977/78 to 1997/98 while; application of pesticides has increased five folds from 1989 to 1998[2]. However, the most dangerous news is that legally or illegally contaminated fertilizers such as zinc-oxy sulphate ($Zn.ZnSO_4$) that was contaminated by cadmium and lead hazardous, non-degradable and sub-standard pesticides as DDT, which have been banned in developed countries, are being imported in to the country[3]. The residues of some pesticides can persist in the environment for more than 20 years[4]. The residues of these chemicals are polluting or contaminating the environment, especially the soil and water, entering in to the food chain, causing threat to human health[5]. So this problem is assumed to be more sever in the near future in our country. In the above context, it is urgent to know as to what extent, the physical environment has been polluted or contaminated by the agro-chemicals to what extent the health aspects of the people of the country have been affected. So, an attempt has been made to determine the present level of pollution and the consequent health problems in the Khamargao Village of Chandipasha Union under Nandail Thana of Mymensingh district in Bangladesh to know the status of pollution level in that area.

MATERIALS AND METHODS

Study area and sampling: The present study were conducted in a fairly agricultural village named Khamargao in Chandipasha Union under Nandail Thana of Mymensingh (Fig. 1) comprising an area of 614 acres with a population of 4061 in 649 house holds[6]. It is about 5 km from Mymensingh district head quarters and 4 km from the Mymensingh-Kishorgonj highway. According to Land Resource Appraisal of Bangladesh for Agriculture development the study area is included in old Brahmaputra flood plain region.

Soil samples were taken at the depth of 0-15 and 15-30 cm and water sample were collected from both surface and sub surface level which include different pond, canal and tube well from 15 December to 30 December 2003. The source of data for the analysis of health impact was collected through the administration of

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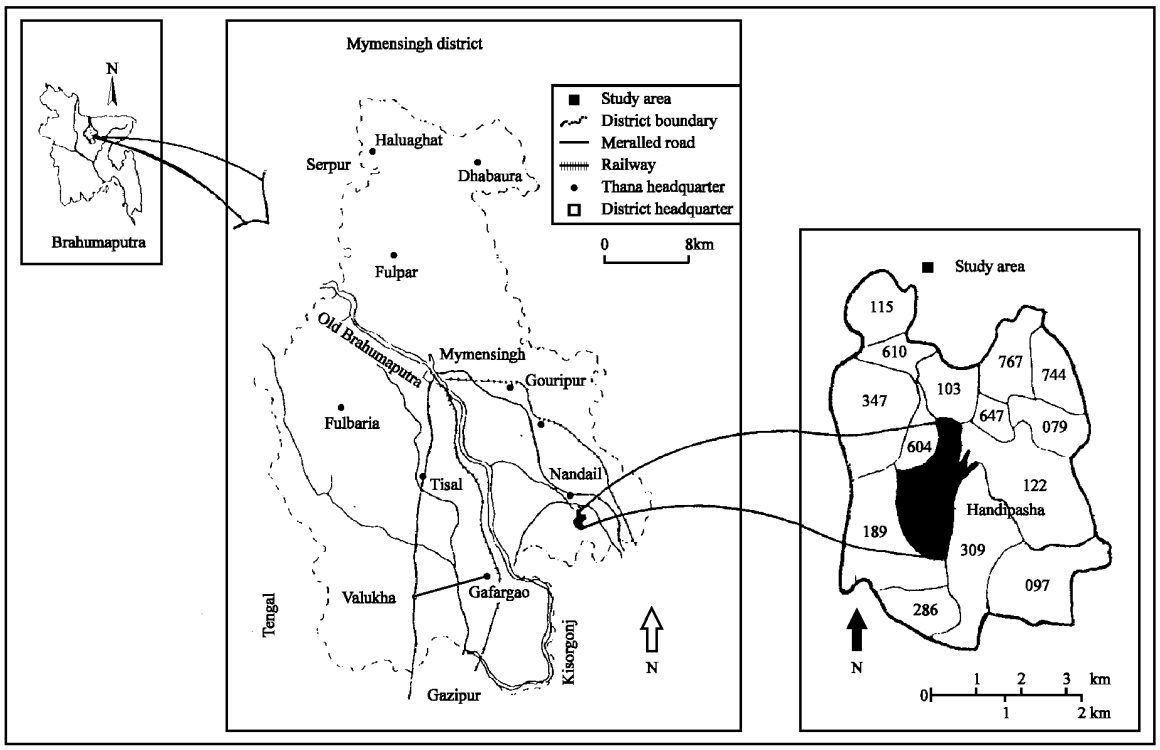

Fig. 1: Map of the study area

questionnaire on selected sample and Rapid Rural Appraisal (RRA) techniques was used mainly to develop generalized agro-ecological transact of the study area.

Data analysis: pH values of the soil and water samples were measured by the digital pH meter (Model-TOA Japan, HM-265). The content of chloride and extractable Phosphorous concentration was determined by the method of Richard[7]. Arsenic concentration was determined according to standard method of Aitken[8]. Some of the moles like; Cu, Zn, Pb, Cd, Cr and Co concentration in soil and water were determined by Atomic Absorption Spectro-photometer. K concentration was determined by the procedure of Aitken[8]. Nitrate (NO_3) was determined by the procedure described by APHA. Dissolved Oxygen (DO) was measured by Azid modification of Winkler's method by Lind[10]. The indicators of human health impacts were measured with percentages by the processing of questionnaire and field survey data from the local people of study area.

Name of the major agro-chemicals, which were used in the study area: In this study, chemical fertilizers refer to all mineral fertilizers and pesticides to all those chemicals, which were used to kill the harmful pest, insects, bacteria and fungi in the agriculture. According to questionnaire survey (2003), the agrochemicals, which were being used in the Khamrgao Village are shown in the Table 1 with their characteristics and possible impurities.

RESULTS AND DISCUSSION

Soil pH: The soil pH value of Khamargao village were found above 5.0 in agrochemicals related plot and 5.9 to 6.3 in non-agrochemicals related plot (Table 2). The plots where agro-chemicals were used are slightly more acidic than the non-agrochemicals related plots. This differentiation may occur due to chemical mixing. Williams[11] has mentioned that chemical fertilizer can play a vital role to change pH condition in soil.

Content of chloride ion in soil: The chloride concentration found for the agro-chemicals treated plots were 1265.5 to 1384.85 ppm and agro-chemicals related plots were found 536.05 to 946.85 ppm (Table 2). This indicates that the agro-chemical treated plots were gradually becoming polluted with respect to chloride content.

Extractable phosphorous concentration in soil: The concentration of phosphate for surface soil in agrochemical treated plot was 51.89 ppm which falls in

Table 1: Name of the major chemical fertilizer used in the study area and their nutrient content and impurities

Fertilizer	Formula	Nutrient	Percentage of nutrient	Form/structure	Impurities
Urea	$CO(NH_2)_2$	Nitrogen (N)	N-46	Granular	----
Single Super Phosphate (SSP)	$Ca(H_2PO_4)_2$+ $CaSO_4.2H_2O$	Phosphorus Pentaoxyde (P_2O_5)	P-8 S-12 Ca-20	Granular	Cadmium (Cd), Fluoride Compounds and other heavy metals (chromium, manganese, nickel and zinc)
Triple Super Phosphate (TSP)	$Ca(H_2PO_4)_2$	Phosphorus Pentaoxyde (P_2O_5)	P-20 S-1.3 Ca-14	Granular	
Hyper Phosphate (HP)	--	Phosphorus Pentaoxyde (P_2O_5)	K-50	--	
Murate of Potash (MP)	KCL	Potassium Oxide (K_2O)		Granular and Powder	--
DAP, HPS and others	$CaSO_4.H_2O$ $ZnSO_4.H_2O$	Gypsum Zinc	S-18 Ca-18 Zn-36	Granular and Powder	Cadmium, chromium (Cr) lead and arsenic.

Table 2: Soil condition of different land level in the study area

	Values are in different land level (ppm or μg g^{-1})			
	Agrochemicals related plot		Non agrochemicals related plot	
Parameters	Surface soil (0-15 cm)	Sub surface soil (15-30 cm)	Surface soil (0-15 cm)	Sub surface soil (15-30 cm)
Soil pH	5.600	5.600	5.90	6.30
Chloride ion content	1265.500	1384.850	946.85	536.05
Phosphoms (P)	51.890	20.100	17.24	9.54
Arsenic (As)	1.200	0.700	0.53	0.58
Cupper (Cu)	29.360	47.040	23.46	10.67
Zinc (Zn)	279.600	378.380	100.09	208.76
Lead (Pb)	40.620	28.000	20.66	18.00
Cadmium (Cd)	0.098	0.013	0.01	0.01
Chromium (Cr)	19.210	15.880	8.27	8.45

Table 3: Water quality of different water level

	Value of water in different level (ppm or mg L^{-1})			
	Agrochemicals related plot		Non agrochemicals related plot	
Parameters	Surface soil	Sub surface	Surface soil	Sub surface
pH	7.00	7.30	7.40	7.00
Nitrate (NO_3)	35.25	12.02	--	6.01
Dissolve Oxygen (DO)	3.30	5.98	6.12	6.50
Chlorine concentration (Cl)	155.02	201.01	121.10	120.21
Phosphorus concentration (P)	15.02	7.98	7.28	3.01
Potassium concentration (K)	2.47	--	--	--
Copper concentration (Cu)	Nill	Nill	Nill	Nill
Zinc concentration (Zn)	0.04	0.26	0.08	0.08
Lead concentration (Pb)	Nill	0.20	--	0.026
Cadmium concentration (Cd)	Trace	Trace	Trace	Trace
Cobalt concentration (Co)	Trace	Trace	Trace	Trace
Arsenic concentration (As)	<0.05	<0.05	<0.05	<0.05

the in the very high phosphate category (Table 3). If this phosphate leaches to water bodies, it may cause eutrophication of water, a form of water pollution. High concentration of phosphate in the surface and sub surface water can be correlated with the high concentration of phosphate in the topsoil. So it can be said that the high concentrations of phosphorus in the agro-chemicals treated plots have mainly come from the phosphate fertilizers.

Arsenic content in the soil: The arsenic concentration of the surface soil in agro-chemicals treated plots found 1.2 ppm, which is 2.2 times higher than the concentration of surface soil in non-agrochemicals treated plots (Table 2). On the other hand, the concentration of arsenic of the subsurface soils of agro-chemicals treated plots were slightly higher than the corresponding depth of the soils where agro-chemicals were not used. This higher content of the topsoil of the agro-chemicals treated plots may be due to the application of contaminated phosphate fertilizer and pesticides. The highest concentration 1.2 μg g^{-1} has been found in the surface soil of a plot where agro-chemicals were used (Table 2). This indicates that some areas of Khamargao Village where the agro-chemicals were being used for a long time may be contamination by the arsenic. Chowdhury[12] has

mentioned that excess chemical fertilizer use and mixing with soil and water is one of the causes of arsenic problems.

Copper concentration: The copper concentration in the soils of Khamargao Village was found 29.36 and 47.04 μg g^{-1} in agro-chemical treated and 23.46 and 10.67 μg g^{-1} in non agro-chemicals treated plots (Table 2). The copper concentration in agricultural soils of more than 0.75 μg g^{-1} is harmful to the plants. The critical limit of copper in the soil is 0.2 μg g^{-1} as set by Bangladesh Agricultural research center (BARC-15). So the concentrations of copper (Cu) was extremely higher than the very high limit of copper as recommended by BARC[13].

Zinc concentration: The analytical data of Zinc concentrations in soil of Khamargao village has found 279.60 and 378.38 μg g^{-1} in agro-chemical treated and 100.09 and 208.76 μg g^{-1} in non agro-chemicals treated plots, respectively (Table 2). The critical Zinc limit of soil for agriculture is 0.6 μg g^{-1}, while more than 1.875 ppm zinc in soil is termed very high content by BARC[13]. The higher zinc content in the topsoils of agro-chemicals treated plots can be attributed to the application of contaminated phosphate and zinc fertilizer.

Lead concentration: Lead is a toxic metal. There is no standard for soil in Bangladesh. The lead concentration in soil of Khamargao Village has found 40.62 and 28.0 μg g^{-1} in agro-chemical treated and 20.66 and 18.0 μg g^{-1} in non agro-chemicals treated plots (Table 2). The concentration of lead in surface soil of agro-chemicals treated plots is 40.62 μg g^{-1}, which is about 2 times higher than the topsoil of the plots where agro-chemical were not used (Table 2). This high concentration of lead in topsoil of agro-chemicals treated plots may be an indication of lead contamination.

Cadmium (Cd) and Chromium (Cr) concentration in soil: The Cadmium concentration in soil of Khamargao village found 0.098 and 0.013 μg g^{-1} in agro-chemical treated and 0.01 and 0.01 μg g^{-1} in non agro-chemicals treated plots (Table 2). The topsoil of agro-chemicals treated plots were concentrated by Lead 0.098 μg g^{-1}, which was not significant. So there was no cadmium pollution in the topsoils of the study area. The lead concentration in the soil of Khamargao village has found 19.21 and 15.88 μg g^{-1} in agro-chemical treated and 8.27 and 8.45 μg g^{-1} in non agro-chemicals treated plots (Table 2). The chromium concentration was found 15.88-19.21 ppm in agrochemical treated plot and 8.27-8.45 ppm in agrochemical treated plot (Table 2). Though there is no standard value for Chromium, it can be said the Chromium contaminates the soils of Khamargao village.

Surface water quality: Different parameters of surface water in the Khamargao village were shown in the (Table 3). It was observed that the surface water of Khamargao village was polluted in terms of nitrate (NO_3), Phosphorus (P) and Dissolves Oxygen (DO), which mainly comes from chemical fertilizer. The value of Nitrate (NO_3) was found 35.25 ppm that is exceeded the allowable limit 10 ppm and the value of phosphate was 15.02 ppm (Table 3) that was also exceeded the standard limit (10 ppm) set by the Department of Environment (DOE-14). This high concentration of Nitrate and Phosphate may lead to eutrophication of water, a form of water pollution, which depletes the Dissolved Oxygen (DO) from the water. This form of water pollution was found in Khamargao Village because the concentrations of dissolved oxygen was low (3.30 ppm) in the surface water whereas the minimum limits of dissolved oxygen in water for the survival of aquatic orgamisms is above 4 ppm. Trace of Cadmium and Chromium have also been found. All the heavy metals were found to be stay within the safe and permissible limits but in the surface water were an alarm of danger.

Sub-surface water quality: The term Sub-surface water indicates the first found ground water after digging different sites of the study area. The value of pH was 7.3, Chloride and dissolved Oxygen were found 201.01 and 5.98 ppm, respectively (Table 3). The value of Nitrate and Phosphate concentration were 12.02 and 7.98 ppm, which were slightly higher than the standard value set by DOE[14]. The heavy metal contamination was found to be 0.20 ppm mainly by the lead (Pb), which is higher than the standard limit (0.05 ppm) for drinking and household use.

Water quality of shallow tube well: The value of pH 7.4, Chlorine concentration and Phosphorus concentration were found 201.10 and 7.98 ppm, respectively (Table 3). The levels of copper (Cu) and lead (Pb) metals in water of shallow tube-well are not the non-detectable range. Like the surface and sub-surface waters, the shallow tube-well level water has the trace of poisonous cadmium and chromium metals, but is within the safe limit.

Water quality of deep tube-well: Different water quality parameter like pH, Nitrate, Dissolve Oxygen, Phosphate, Potassium, Copper, Zinc, Lead, Cadmium and Arsenic were analyzed and found that all the values were the allowable limit below (Table 3).

Impact on human health:

Effect on eyes by occupation: It was found that as a applicator farmer 35.5% people who were suffering in poor vision of eye problems and 26.7% as a non-applicator farmer were also being this problem (Table 4). The next affected group was fisherman, which was one forth (25%) of the total affected people and followed by service 20% and business 13.3% (Table 4). This problem is higher among the applicator farmers and non-applicator farmers who have maximum possibility of exposure to the chemical fertilizer and pesticides compared to other occupations. It was also observed that the other parameters of eye problems were higher among the applicator and non-applicator farmer than the other occupation people of study area (Table 4).

Eyes effect by age group: It was found that 75.7% old people (60+years) who were suffering in poor vision of eye problems (Table 4). The percentages of eye-affected people from older adult to adolescents have decreased significantly being 18.3, 7.8 and 5.3% for older adults, young adults and adolescent, respectively (Table 4). Infants were not affected by the mentioned eye problems.

Respiratory tract effects by occupation: Fishermen and applicator farmers were the most vulnerable for respiratory tract effects and they were suffering in cold and cough 37.5 and 33.3% by the respiratory tract problems (Table 5). Non-applicator farmers were the third suffering group (26.7%) while the respiratory problems were not significant among the servicemen (15%)and businessmen (13.3%), respectively (Table 5). This indicates that the respiratory tracts of the fishermen and applicator farmers were affected more than the other people due to application of agro-chemicals by their occupation. Long-term exposure to chemical fertilizers with impurities of heavy metals and pesticides may cause chronic cough, cold, tenderness, decreased chest expansion, bronchial asthma and other abnormal lung findings[15].

Respiratory tract effects by age group: It was found that 67.6% old people (60+years) who were suffering in cold and cough of respiratory tract problems and a significant number of infants (25%) were also being the respiratory problems (Table 5). On the other hand, the percentages of people suffering from respiratory problems were lower in the other age groups of being 13.3, 10.8 and 7.8% for adolescents, older adults and young adults, respectively (Table 5). One of the reason of such situation may be due to inadequate natural preventive capability of the immune systems of the infants and old people than adolescents, young adults and old adults but the slow and continuous intake of the residues of the irritating agro-chemicals from the environment was assumed responsible also.

Effect on skin by occupation: Fishermen and applicator farmers were the most skin diseases affected people and they were suffering in eczema 75 and 51.7% by the skin problems (Fig. 2). Non-applicator farmers were the third suffering group (33.4%) and other occupation among the servicemen (25%) and businessmen (33.3%), respectively (Fig. 2). This indicates that the skin problems of the fishermen and applicator farmers were being affected more than the other occupations due to using of chemical fertilizer and pesticides, especially in the pre-monsoon and post monsoon season when the farmers and fishermen have to work in the water, this problem becomes too severe to work. Pesticides and impurities of chemical fertilizer enter the body through skin, not through the respiratory tract[15].

Effect on skin by age group: It was found that 67.3% old people (60+years) who were being suffering in eczema of skin diseases (Fig. 3). The percentages of skin diseases affected people from older adult to infants have decreased significantly being 34.2, 12.4, 10 and 7.5% for older adults, young adults, adolescent and infants, respectively (Fig. 3). One of the causes of the highest percentage of the skin problems for the older age group may be the fact that they were actively engaged in agriculture and are associated with the application of Agro-chemicals. On the

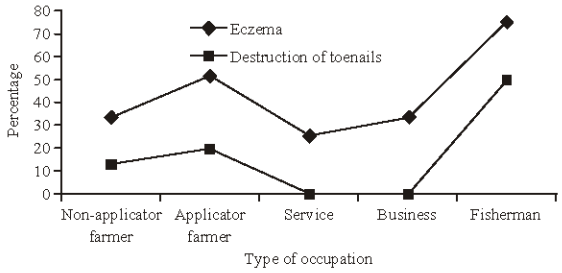

Fig. 2: Effect on skin by occupation of the people in the study area

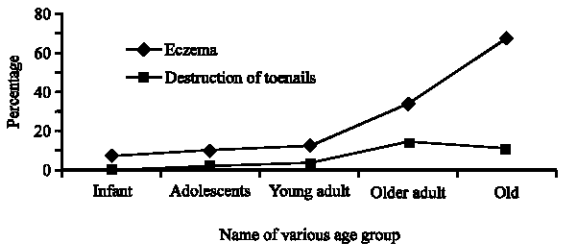

Fig. 3: Effect on skin by age group people in the study area

Table 4: Effect on eyes by occupation and age group of the people in the study area (%)

	Occupation					Age groups				
Indicators of eye effects	Non-applicator farmer	Applicator farmer	Service	Business	Fisherman	Infants (0-4 years)	Adolescents (5-14 years)	Young adult (15-34 years)	Older adult (35-59 years)	Old (60+years)
Pterygium	26.7	21.7	15.0	13.3	12.5	0	2.7	11.8	8.3	56.8
Encroached membrane on pupil	20.0	16.7	10.0	6.6	0.0	0	1.3	2.7	3.3	54.1
Poor vision	26.7	35.5	20.0	13.3	25.0	0	5.3	7.8	18.3	75.7

Table 5: Effect on respiratory tract effects by occupation and age group of the people in the study area (%)

	Occupation					Age groups				
Indicators of eye effects	Non-applicator farmer	Applicator farmer	Service	Business	Fisherman	Infants (0-4 years)	Adolescents (5-14 years)	Young adult (15-34 years)	Older adult (35-59 years)	Old (60+ years)
Cold	26.7	33.3	15.0	13.3	37.5	25.0	13.3	7.8	10.8	67.6
Cough	26.7	33.3	15.0	13.3	37.5	25.0	13.3	7.8	10.8	67.6
Bronchial asthma	16.7	23.3	6.7	13.3	25.0	7.5	3.3	1.3	1.7	54.1

other hand, about 10% old people were being suffering from destruction of the toenails against 14.8, 3.3 and 2.0% for older adults, young adults and adolescents but Infants were not being affected by the mentioned skin problems (Fig. 3).

CONCLUSIONS

The soil pollution in the Khamargao Village was significant. The present water qualities of the study area indicate that the surface water was polluted in terms of nitrate (NO_3), phosphorus (P) and Dissolve Oxygen (DO). The high concentration of P and NO_3 may cause eutrophication in the surface water, which has depleted the content of dissolved oxygen in surface water. Sub-surface and shallow tube-well water pollution occur only in terms of P and NO_3. Deep tube-well was safe in terms of parameters used in this study. Eye diseases were higher among the applicator farmers and non applicator farmers, respiratory tract problems predominate among the fishermen, applicator and non-applicator farmers and skin diseases among the fishermen, applicator and non-applicator farmers. So the main victims of agrochemicals were applicator farmers. The health analysis by age group appears with the finding that in the most cases the old people (60+years) and older adults (35-59 years) have the highest percentages of victims. This may be due to the fact that they have higher possibility of having longer exposure to the agro-chemicals.

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