Environmental and Health Impacts Associated with Usage of Agrochemicals in Mindu Dam Catchment Area, Morogoro, Tanzania

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Abstract: *A field based study was conducted during 2004 – 2006 to assess the environmental, human and animal health risks associated with usage of agrochemicals in Mindu dam catchment area (MDCA), in Morogoro, Tanzania. Heads of 268 households were interviewed using a questionnaire with structured and semi-structured questions. Fertilizers, insecticides and fungicides were the most commonly used agrochemicals in tomato production, which was the main crop cultivated. Endosulfan was the only organochlorine pesticide used in vegetable production. The majority of the farmers purchased agrochemicals that were repacked in unlabelled non-original containers, which were later reused for domestic purposes. About 73% of the farmers applied agrochemicals without protective gears. High risk groups to agrochemical exposure in the area were men, retailers and children. Farmers' perceived impacts of agrochemical usage included getting sick, deaths of people and animals and environmental pollution. Information obtained from this study was used to identify appropriate foci and target groups for interventions to reduce the health risks associated with the usage of agrochemicals in the area. This assessment identified three foci and target groups for interventions: training of farmers on good agricultural practices, strengthening agricultural extension services, and reinforcing regulatory services.*

Key words: aquatic environment, fertilizers, humans, pollution, pesticides

INTRODUCTION

Agriculture is the leading economic sector in Tanzania, contributing to about 28 % of the total Gross Domestic Product (GDP), 85% of export products and is a dependable means of livelihood of about 80% of the total population (CWF, 2013). This sector provides employment to over 85% of the country's workforce. The optimal productivity in agriculture depends on the use of a wide range of agrochemicals that include pesticides and fertilizers. Agrochemicals contribute to increased crop yield, minimize crop and livestock losses due to pests and diseases and improve the quality of agricultural and animal products (Dinham and Malik, 2003; FAO, 2003). Most of agrochemicals used in Tanzania are imported from developed countries. Because of the prevailing poor regulatory frameworks and high level of illiteracy, use of agrochemicals leads to high environmental and health hazards (Mbakaya *et al*., 1994; Kimani and Mwanthi, 1995; Ngowi and Semali, 2011). Use of agrochemicals in most of the African developing countries is relatively low because of poverty, dependency on unreliable rains and indifferent soils that favours more the small and medium than large scale farmers (Mansour, 2004). Developing countries consume more than 20% of the world production of agrochemicals and are responsible for approximately 70% of the total number of cases of acute poisoning occurring in the world, which corresponds to more than one million cases (ILO 2004). Large agricultural worker populations in the third world countries are increasingly been exposed to pesticides, including those that are highly restricted and/or banned in industrialized countries. For instance, Tanzania still uses some of the extremely hazardous (WHO class 1a) and higly hazodours (class 1b) pesticides that are banned in developed countries (WHO, 2010). Such pesticides are mostly used in large quantities in large and medium scale commercial farms (Ngowi *et al*., 2007) and in small quantities in smallholder vegetable farms (Ngowi and Semali, 2011).

During 1970's to 1980's, the Government of Tanzania engaged in a programme that supplied high amount of agrochemicals to small-scale farmers for free or on credit at a subsidized price so as to improve agricultural production (CWF, 2013). This incentive to small-scale farmers increased the demand for agrochemicals. In 1990's the government ceased to provide full subsides to most of the cash crop growers (cotton, coffee and cashew nuts) and hence only few farmers were able to purchase and use adequate amounts. Under both scenarios of increased and decreased usage of agrochemicals in Tanzania, limited studies were carried out to examine the associated health hazards in some few parts of the country (Mbakaya *et al*., 1994; Ngowi *et al*., 2001b). Most of the studies were carried out in coffee and cotton farms where agrochemicals were relatively used in high quantities. Given the broad array of climatic and agroecological diversity that supports production of various crops and livestock, the previous studies did not inform on the overall situation of agrochemical usage and the associated health risks in the country.

Mindu dam catchment area (MDCA) located in Morogoro urban and Mvomero districts in Tanzania has an area of about 303 km^2. This area lies in the slopes of Uluguru Eastern Arc Mountains and has permanent and seasonal rivers that flow into Mindu dam. Over 70% of about 750,000 residents in Morogoro urban and peri-urban areas depend on water from the Mindu dam for irrigation, fishing and domestic purposes. Having reliable sources of water for irrigation during the dry season and being close to the urban area, the MDCA is suitable for agriculture that offer opportunities for marketing the produce all year round. Because of these opportunities, all suitable land in MDCA is intensively used for agriculture and mostly for horticultural crops. The fact that agriculture is the most dependable means of livelihood and source of income by the majority in MDCA, agrochemicals are used without considerations of their fate in the environment, humans and animals.

The aim of this study was to determine the type and quantities of agrochemicals used, methods of their application and handling and their contribution to environmental pollution and to the perceived human and animal health hazards.

Information obtained from this study would provide a basis for suitable interventions to reduce environmental pollution and health risks.

MATERIALS AND METHODS

Study Area and Population

This study was conducted in eight villages within MDCA in Morogoro, namely Manza, Mlali, Kipera, Changarawe, Tangeni, Konga, Vikenge and Kauzeni (Figure 1).

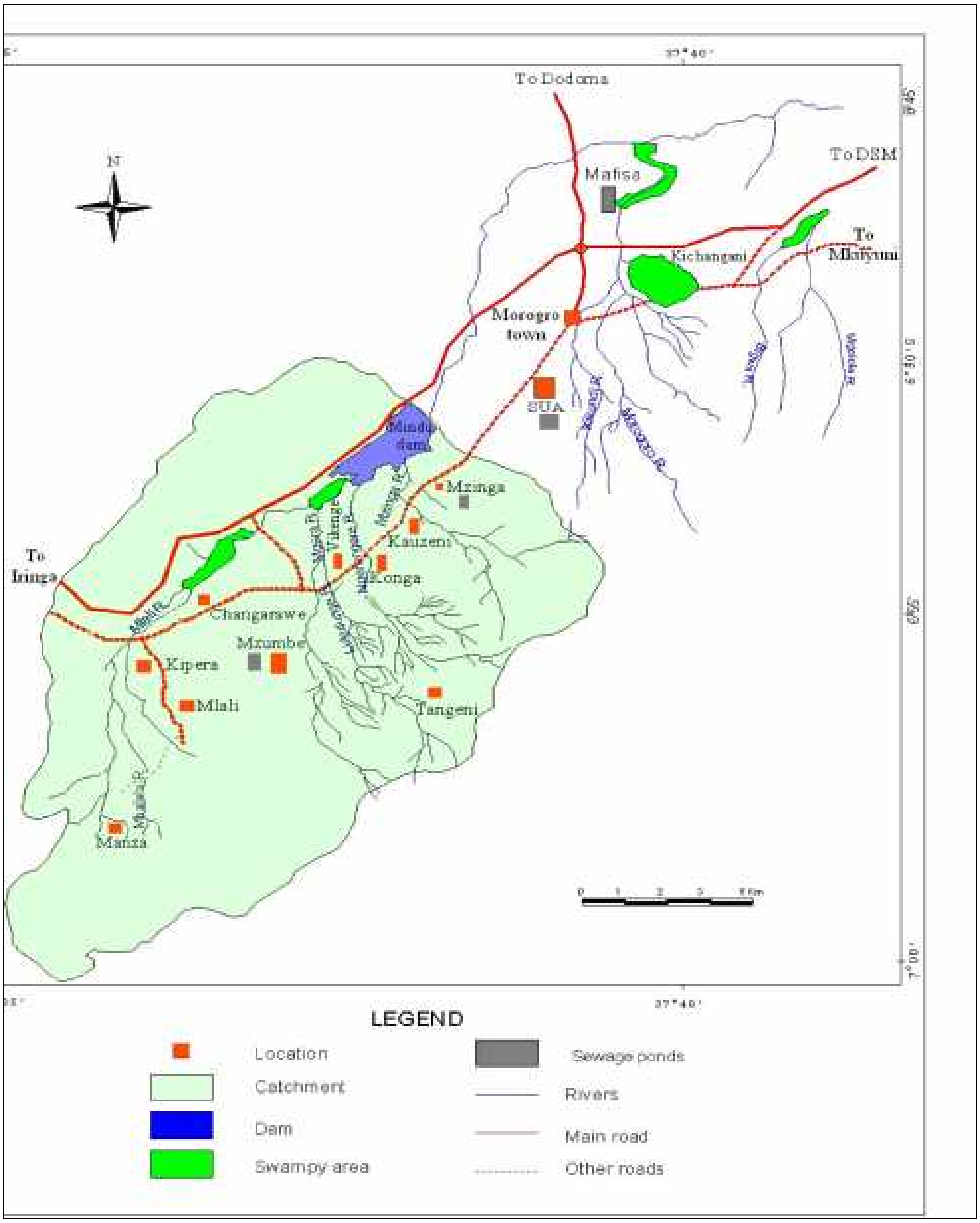

Figure 1: Map Showing the Mindu Dam Catchment Area, and Rivers in Morogoro Municipality

These villages were selected purposively because they were within MDCA, using main rivers in the catchment and were within the geographical area where other studies on fish biomarkers for monitoring environmental pollution were conducted during the same period. A household was the study unit and the inclusion criterion was farming (crop farming and/or keeping of livestock), applying agrochemicals and willingness to participate in the study. A total of 268 households in the selected villages were included in the study. Depending on the village size and availability of water bodies (rivers and wells), the number of selected households for this study was variable.

Ethical Consideration

Verbal consents were given by the village leaders and the study farmers after the principal author informed them on the purpose and possible benefits of the study. Information obtained from the farmers was kept confidential and names of the study farmers were anonymous.

Data Collection

A standardized questionnaire with structured and semi-structured items was used during face-to-face interviews with one respondent in each of the selected households. The questionnaire was administered by the researchers themselves. The information collected included respondent's socio-demographic variables, crops and animal production practices, uses of agrochemicals, irrigated farming and health related issues (Table 1). Although the study was conducted during 2004-2006, data collection included retrospective information of 2002 to 2006.

Table 1: Type of Information Collected During the Survey

Type of Information	Specific Data Collected Using a Questionnaire
Respondent's socio-demographic variables	Age, sex, education, occupation and village of residence
Uses of agrochemicals in agriculture	Types of agrochemicals and management
	Pesticide uses: types, sources, storage, season of use and frequency, application methods and responsible person, use of protective gears, disposal of pesticide containers, sources of information on pesticides applications and awareness of pesticide environmental pollution
	Fertilizer uses: types, sources, use frequency and availability
Irrigated farming	Water availability, types of available water bodies, distance of water body from the farm and possible sources of water pollution
Health related issues	Knowledge about human and animal health hazards (possible symptoms related to pesticides uses, human and animal deaths due to pesticide poisoning)

While conducting the interviews, direct observations were made on agrochemicals that were available at the farm during the day of visit. All agrochemicals were examined for validity of dates, containers, and presence of instructions for application and handling. Finally, farmers were also interviewed on awareness regarding sources of pollutants in MDCA other than agrochemicals.

Data Analysis

Data were analysed using Epi Info version 6 (Coulombier *et al*., 2001). Descriptive statistics of different factors were computed to obtain proportions and their 95% confidence intervals (Cis) where necessary. Because of the observed similarities in farming practices and socio-cultural factors, farmers in all of the study villages were considered as one population during data analysis. Therefore, no statistical comparisons between villages were made.

RESULTS

Demographic Information

A total of 268 smallholder farmers were interviewed in the selected households in MDCA. Of these, 35 were from Changarawe, 40 Kauzeni, 60 Kipera, 42 Kongavikenge, 27 Manza, 43 Mlali and 21 Tangeni villages. Konga and Vikenge were merged to one village (Kongavikenge) because initially they were one village hence at the time when this study was conducted (2004 – 2006), farmers were cultivating across the two villages. The geographical location of the villages in relation to the Mindu dam and associated rivers is presented in Figure 1. The mean age of respondents was 38 years, with the standard deviation of 13 years (Figure 2).

Figure 2: Age Groups of Respondents in MDCA

Out of 268 households investigated, 89% were headed by males and 11% by females. About 94% of the respondents were entirely engaged in farming while the remaining 6% were employed in cadre works but were also involved in farming. Eighty-two percent (82%) of respondents had Tanzanian basic education, 11% had secondary education, 6% had college education (including teachers, nurses, medical assistants and agricultural extension officers who were also involved in farming), while 1% had no formal education.

Crop and Livestock Production

Over 80% of farmers were growing tomato, maize, and rice, while less than 50% were growing other horticultural crops that included sweet potato leaves, Chinese cabbage, okra, amaranths, spinach, onions, lettuce, carrot, cauliflower, egg plants, green beans, leaks, green pepper and pumpkin leaves. The total cropped hectares per year were 340, 357, 392, 390 and 407 for 2002, 2003, 2004, 2005 and 2006 respectively. Sizes of cropped land excluded crops that had countable trees such as mango, orange, avocado, coconut, palm oil and breadfruit whose total number was

1831, 1826, 1877, 1870, 1902 and 2004 for 2002, 2003, 2004, 2005 and 2006 respectively. Different animal species were kept in the study area. These included exotic dairy and local beef cattle, goats, sheep, pigs, local chickens, ducks, guinea fowls, dogs, cats, donkeys and rabbits. Local chickens, ducks and goats were the animal species that were kept by the majority of the farmers. Only two farmers owned local cattle, one with 100 and the second farmer with 35 heads of cattle. Out of 268 respondents, 153 (57%) were keeping animals and disposed wastes as manure.

Handling of Agrochemicals

Tables 2 – 5 present the types and quantities of agrochemicals used by farmers in MDCA during the period of 2002 to 2006. The highest amount was used in tomato and very little in other crops. Both root and foliar types of fertilizers were used (Table 2).

Table 2: Type and Quantity of Fertilizers in Kilogram (kg) or litres (L) used in MDCA During the Period of 2002 – 2006

Trade name	Ingredients	2002	2003	2004	2005	2006
UREA (Kg)	Urea	8702	8309	8980	8888	8982
CAN (Kg)	Calcium and nitrogen	2552	2914	3063	2998	3040
TSP (Kg)	Triple superphosphate	75	70	86	84	79
DAP (Kg)	Diammonium phosphate	610	755	805	798	803
Booster (L)	Nitrogen, phosphorous, potassium and trace elements	100.5	97	105	103	111
MultK (Kg)	Potassium and nitrogen	36	578	127	402	507
SA (Kg)	Ammonium sulphate	1139.5	909	1276	1200	1207
NPK (Kg)	Nitrogen, phosphorous and potassium	1525	2470	2990	2700	2940
Polyfeed (Kg)	Nitrogen, phosphorous and potassium	63	96	80	76	88
Byfolan (L)	Nitrogen, phosphorous, potassium and trace elements	31	42	46	64	60

Insecticides used were in the groups of organophosphates, synthetic pyrethroids, organochlorines and carbamates (Table 3).

Table 3: Insecticides in kilogram (kg) or litres (L) used in MDCA during the period of 2002 –2006

Trade name	Common name	Group	2002	2003	2004	2005	2006
Karate (L)	Cyhalothrin lamda	P	122	127	130	133	132
Selecron (L)	Profenofos	OP	87	96	105	100	343
Sumithion (L)	Fenitrothion	OP	8	12.5	18	16	17
Thionex (L)	Endosulfan	OC	35	49	63	76	103
Dursban (L)	Chlorpyrifos	OP	0	0.25	1	1	0.75
Sevin dudu dust (Kg)	Carbaryl	CA	0.1	7	7.5	9	21
Rogor (L)	Dimethoate	OP	2	2.5	5	4.25	5.75
Diazinon (L)	Diazinon	OP	4	2	12	21	13
Actellic (L)	Pirimiphos-methyl	OP	0.25	0.25	0.5	0.5	3
Fenvalerate (L)	Fenvalerate	SP	0	0.5	5	4.5	6
Decis (L)	Deltamethrin	SP	2	2	4	3.25	3.75
Fipronil (L)	Phenylpyrazole	PH	0	1	1	1	1

CA: Carbaryl OC: Organochlorine OP: Organophosphate
P: Pyrethroid PH: Phenylpyrazole

Other groups of pesticides included fungicides (Table 4), herbicides, acaricides (organochlorines, synthetic pyrethroids and carbamates) and rodenticides.

Table 4: Fungicides in kilogram (kg) or litres (L) that were used in MDCA 2002 – 2006

Trade name	Common name	2002	2003	2004	2005	2006
Dithane (Kg)	Mancozeb	561	589	708	700	680
Banco (L)	Chlorothalonil	40	61	90	91	106
Cobox (Kg)	Copper oxychloride	110.5	156	203	200	213
Blue copper (Kg)	Copper sulfate	81.5	89	110	121	115
Milthane (Kg)	Mancozeb	0	2	2	1	2
Antracol (L)	Dithiocarbamate	24.5	43	60	58	64
Bravo (L)	Chlorothalonil	51.5	52	67	70	62
Baylaton (L)	Triadimefon	0	1	0	2	1
Ridomil (Kg)	Metalaxyl + mancozeb	9	8.5	24	31	30
Benlate (L)	Benomyl	0	0	1	1	1

High proportions and quantities of insecticides used were pyrethroids and organophosphates and to a less extent carbamates and organochlorines. Endosulfan (Thionex®) was the only organochlorine pesticide used. In animals, carbaryl was mostly used in local chickens while chlorfenvinphos was used for control of ectoparasites in cattle, sheep, goats and pigs.

Agrochemical suppliers in Morogoro Municipality were the secondary sources of agrochemicals sold to local shops in villages that served as primary sources to the farmers. The farmers could also buy the agrochemicals directly from the major shops in town. The main sources of agrochemicals to farmers (end users) were Mlali (38%), Morogoro Municipality (35%), Kipera (20%), Kauzeni (2.5%), Changarawe (0.5%) and other sources (3%) that included open markets and street vendors. The majority of the farmers purchased agrochemicals in small quantities that were re-packed locally in non-original containers without safety instructions for use and handling. Most of the farmers used knapsack sprayers and a common practice was to mix insecticides and fungicides together in the sprayer with the intention of saving time and the amount of water for reconstitution. Months at which agrochemicals were applied at high frequency are shown in Figure 3.

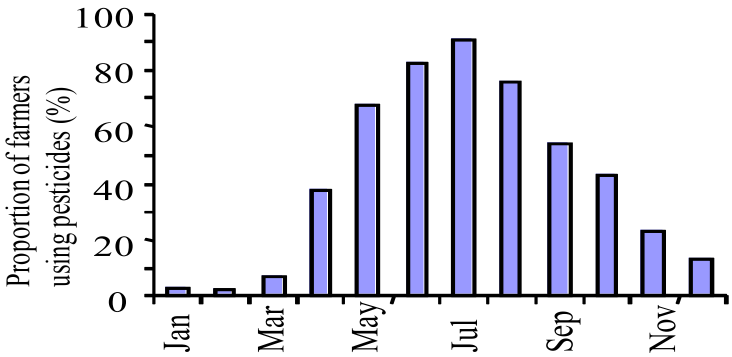

Figure 3: Proportion of Respondents Applying Pesticides in Different Months

July was the peak month at which the highest amount of agrochemicals was used. Agrochemicals were mainly applied by men (84.5%) and to a lesser extent by others including women (4%), children (4.5%) and any 7% (men, women, children).

During handling of agrochemicals, about 78% of the farmers did not use any protective device. For those who used protective devices, 11% used overcoat, 6% coverall, 1% eye protective glasses, 13% long rubber boots and 1% others that included head covers (Figure 4).

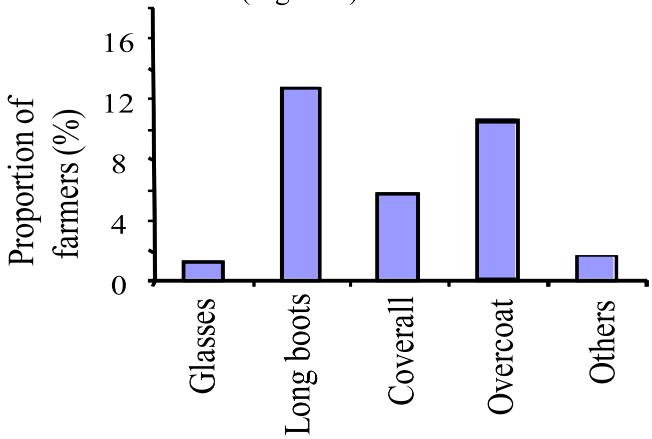

Figure 4: Proportion of Farmers that used Different Pesticide Protective Devices

Agrochemical leftovers from previous season(s) were also reused by 70% of the farmers. The proportion of farmers with different remaining agrochemicals was 27% for fertilizers, 33% for fungicides, 37.5% for insecticides and 0.5% for herbicides. The leftovers were stored in different places (Table 5). Such agrochemicals were stored mainly in plastic bags (45%) and paper bags (37%). Other storage containers included fertilizer bags (4%), plastic bucket, metal box and cupboards each at 2% and in travel bag at 2%.

Table 5: Storage practices of agrochemicals in MDCA during 2002 – 2006

Storage practices	n	(%)	95% Confidence interval
In the agrochemical store	268	30.5	19 - 33
In animal houses	268	5	3 - 12
In the bedroom	268	23	16 - 30
In the food store	268	10	13 - 26
In the kitchen	257	4	4 - 13
In the sitting room	257	11	5 - 15
Within reach of children	268	20	14 - 27
Close to a fire	268	6	2 - 10
Close to food	268	13	10 - 22
Non-original containers	263	63	46 - 64
Both original & non-original containers	244	16	9 - 22.5
Containers without instructions	243	50	40.5 - 59
Agrochemicals without instructions	244	47	38 - 56
Agrochemicals with and without instructions	244	24	9 - 22.5
Other places	257	17	4 - 13

Reported Health Risks in Humans and Animals Associated with Application of Agrochemicals

Health risks in humans associated with application of agrochemicals are shown in Table 6.

Table 6: Clinical Signs in Humans Associated with Handling and Application of Agrochemicals in MDCA During 2004 - 2006 (N = 268)

Side effects in humans	%	95% CI
Body itching	80	70 - 85
Eye itching, swelling and pain	16	11 - 25.5
Abdominal discomfort	9	0.5 - 13
Feeling weak	16	7.5 - 21
Sneezing	7	5 - 16
Headache	25.5	9 - 30
Running nose	25.5	16- 32
Shrinkage of skin	1	0 - 5
Drying and exfoliation of skin	2	0 - 5
Hoarseness of of voice	1	0 - 5
Chest pain	12	3 - 13
Coughing	10	4 - 14
Chocking	2	0.2 - 6
Backache	0.5	0 - 5
Drying and irritation of throat	2	0.5 - 7
Difficult breathing	1	0 - 5
Loss of appetite	1	0 - 5
Burning of skin	3	2 - 11
Excessive sweating	4	0.5 - 7
Nausea	3	0.2 - 6

Most of the side effects reported were as a result of direct exposure to agrochemicals, a problem that was aggravated by lack of protective gears. Out of 268 respondent, 39 (14.7%) reported to had seen cases of human deaths resulting from pesticide poisoning. Among observed cases of people who died from pesticide poisoning as reported by respondents, 55% were from accidental poisoning, 30% intentional (suicide cases) and 15% were from unidentified reasons. Ways in which humans and mostly children were accidentally poisoned by pesticides included drinking pesticides that looked like other edible products such as milk and honey by mistake as well as by using pesticide empty containers to pack food or use to collect drinking water.

The side effects of agrochemicals in animals were reported by 27% of the respondents and they included death (25%) and suspected signs due to poisoning (2%). Animals that were reported to have died from agrochemical poisoning included 8 cattle, 2 goats, 13 local chickens, 3 ducks and 6 guinea fowls. Cattle and goats died because they grazed around farms that were sprayed by pesticides. Local chickens, ducks and guinea fowls died through several exposure ways that included eating sprayed vegetables, eating rodents or insects that had been poisoned, or through intentional poisoning by enemies.

Environmental Pollution by Agrochemicals

Agrochemical leftovers were disposed by 68% of the farmers by either throwing at the farms (9%), burying (19%), throwing in rivers (2%), donating to friends (25%), selling (3%), dropping into pit latrines (33%), disposing in waste pit (2%), or by burning (5%). The remaining proportion of farmers (32%) was keeping the leftover for use in subsequent seasons. Environmental pollution by agrochemicals was also due to repacking in non-original containers as well as due to keeping of repacked agrochemicals outside directly under the sun during daytime. Apart from environmental pollution through leakage and evaporation, this malpractice also resulted in reduced quality of agrochemicals. The consumption of agrochemical per cropped hectare was calculated based on data for tomato in which most of agrochemicals were used. The intensity values in tomato for agrochemicals are shown in Table 6.

Table 6: Intensity of agrochemicals used on tomatoes in MDCA during 2002 – 2006

Factor	2002	2003	2004	2005	2006
Fertilizers					
Amount of solid fertilizer applied to all crops (metric tons)	15	16	18	17	18
Amount of liquid fertilizers applied to all crops (litres)	146	159	150	167	163
Amount of solid fertilizer applied to tomatoes only (MT)	14	16	15	17	15
Amount of liquid fertilizer applied to tomatoes only (L)	143	156	155	180	178
Total cultivated land size (Hectares)	340	357	392	390	407
Total cultivated land size for tomatoes (Hectares)	82	83.5	90	92	93
Intensity for solid fertilizes applied to tomatoes (MT/ha)	0.2	0.2	0.2	0.2	0.2
Intensity for liquid fertilizes applied to tomatoes (L/ha)	1.8	1.9	1.9	2.0	2.0
Pesticides					
Amount of liquid pesticides applied to all crops (L)	380	453	480	453	486
Amount of solid pesticides applied to all crops (kg)	778	853	890	900	930
Amount of liquid pesticides applied to tomatoes (L)	376	447	500	509	498
Amount of solid pesticides applied to tomatoes (kg)	778	853	890	900	930
Intensity for liquid pesticides applied to tomatoes (L/ha)	4.6	5.4	5.6	5.5	5.5
Intensity for solid pesticides to tomatoes (kg/ha)	9.5	10.2	9.9	9.8	10

The main sources of water for farming activities were Mlali (26%), Lukulunge (25%), Mzinga (3%), Mgera (13%) and Manza (13%) rivers, which drain to Mindu dam. In addition there were other sources (20%) that included wells, ponds and seasonal streams. Figure 5 illustrates the proportion of farmers with their respective distance from the farms to the rivers or other sources of water. Most of the farmers were cultivating within 100 metres from the riverbanks, a practice that contributed to water pollution by agrochemicals.

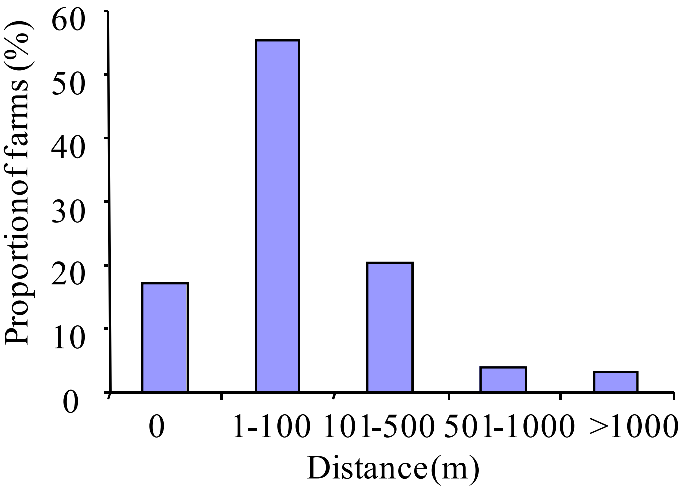

Figure 5: Proportion of Farmers Cultivating at Different Distances from the River Banks

For domestic purposes, sources of water included tap water (76%), rivers (48%), deep wells (21%) and springs (2%).

Unintended Uses of Pesticides in MDCA

In MDCA, some pesticides were used for unintended purposes. Endosulfan was used in fishing, killing of wild animals such as monkeys and wild pigs that destroyed crops, or killing dogs and cats that preyed on chickens. Cyhalothrin lamda (Karate®) was used to control fleas, mites and lice in chickens. Diazinon (Diazinon®) indicated for ectoparasite control in animals was used to control armyworms in maize. Chlorfenvinphos (Steladone®), an acaricide against ticks was used to control aphids in tomato and onions. In addition, sumithrin piperonyl butoxide, an insecticide for control of mosquito was used as fungicide in tomato production.

DISCUSSION

This study examined objectively the environmental as well as human and animal health risks associated with the usage of agrochemicals in MDCA in Morogoro Tanzania. Majority of the farmers in the study area were in the most active and productive age, they had primary school education with limited understanding of English language. These farmers had no training in good agricultural practices (GAP) including proper use and safe handling of agrochemicals. Since most of agrochemicals used in Tanzania are imported and have instructions in English, which is not understood by the majority of farmers, this leads to misuse and mishandling of such chemicals. Similar, language barriers in communities with primary education were previously reported (Nonga *et al*., 2011) in Manyara basin, Tanzania and in Ethiopia among farmers and pesticide sprayers (Mekonnen and Agonafir, 2002). It is recommended that farmers be trained in GAP and where possible instructions for agrochemical usage should be translated into Swahili, the National language that is understood by the majority of the Tanzanians. This would reduce the misuse and mishandling of agrochemicals and thus safeguard human, animal, and environmental health.

Because of the small size (0.25 – 2 acres) of cropped land per household with 2 – 3 farming cycles per year, observed agrochemical intensities were low (Table 6) suggesting minimal direct environmental impact. The minimal environmental risk was also evidenced by the limited use of organochlorine pesticides in which only endosulfan was used. Furthermore, carbaryl was the main pesticide that was used for treatment and control of chicken fleas, mites and lice since local chickens were the dominant livestock kept in MDCA. Acaricides (organophosphates and pyrethroids) were used to a limited extent in cattle, goats, sheep and pigs. The fact that most of the animal wastes were disposed in the farms as manure and only limited quantities of pesticides were used in animals demonstrates that the contribution of livestock keeping to environmental pollution in MDCA was also minimal. However, indiscriminate use of animal manure on agricultural land may contribute to nutrient enrichment in water bodies due to run-off causing eutrophication. This is another form of pollution that was evident in Mindu dam. It may lead to several undesirable effects including water body disappearance and poisoning as a result of algae blooms and the associated phycotoxins (Komárek, 2005).

Formulations of agrochemicals that were used in the study area by all tomato-growing farmers were in the groups of fertilizers, insecticides, fungicides and rodenticides. Most of the agrochemicals used were registered by the Tropical Pesticide Research Institute (TPRI) (URT, 2011). Of much interest was the absence of organochlorine pesticides, which fall within the group of persistent organic pollutants (POPs) in MDCA. These findings demonstrated that although Tanzania and in particular MDCA was using agricultural POPs for decades, it is now under control and possibly as a result of implementation of the Stockholm Convention on POPs in which Tanzania is among countries that signed, adopted and ratified it since 2001 (Madete and Enock, 2005). This is regarded as a positive attribute in comparison with findings from other studies conducted in Tanzania in which organochlorine pesticides such as aldrin, dichlorodiphenyltrichloroethane (DDT), dieldrin, camphechlor and lindane were used in food crops and animals (Mbakaya *et al*., 1994; Ngowi *et al*., 2001a). In the present study it was revealed that the latest use of agricultural POPs in MDCA was in 1990-1991. Evidence of previous rather than current use of first category of POPs such as DDT, chlordane, hexachlorobenzene and hexachlorohexane in MDCA was also observed in another study in which insignificant levels of organochlorine pesticide residues were detected in fish and freshwater shrimps in Mindu dam (Mdegela *et al*., 2009).

Most of farmers in MDCA are poor and with their low income could not afford agrochemicals in large quantities in the original containers. This situation forced them to purchase agrochemicals that were repacked in small quantities in non-original containers without use, handling and safety instructions. Because these containers did not seal properly, agrochemicals were continuously released on the environment through leakage and evaporation. In several agrochemical stores, the repacked pesticides were kept outside during daytime in order to minimize the amount of evaporating chemicals that resulted to unpleasant working environment inside the shops. Some farmers purchased small quantities of agrochemicals directly in knapsack sprayers or in other containers such as those used for beverage and syrup drugs. Apart from the potential for causing environmental pollution and health hazards, repacking of agrochemicals resulted into adulterations that lead to their poor efficacy a challenge that was frequently reported by farmers. Re-using the pesticide empty containers for other domestic purposes increases the risk to the human health. This study recommends strengthening of regulations regarding selling of agrochemicals in Tanzania (ILO, 2004).

According to Mansour, (2004), agrochemicals in particular pesticides are potential risks to the farmers and farm workers, workers in pesticide factories, populations that live in areas of intensive pesticide use or production and populations that are exposed to persistent pesticides in the form of chemical residues in foods. Based on these criteria, the risk groups in MDCA were farmers and farm workers as well as populations that lived in areas close to the tomato farms. However, in the current study additional risk groups were identified that included retailers who were involved in repacking and selling agrochemicals in smaller quantities in non-original containers and people who reused pesticide containers for food and drinks. The practice of disposing agrochemicals and agrochemical containers, washing farm clothes and hands, and bathing in rivers after application of agrochemicals was identified as a risk factor that led to pollution of water bodies. It is known that agrochemical residues in water and in the environment are potential sources of chronic exposure pathways (WRI, 1996), a phenomenon whose effect in MDCA needs further investigations before interventions can be made.

In the present study, application of agrochemicals was carried out mainly by men (farmers and labourers) and to a lesser extent by women. Subsequently, most of the health hazards associated with application of agrochemicals were much higher in men than in women, an observation that was in agreement with findings from previous studies (McConnell and Hruska, 1993; Kimani and Mwanthi, 1995; Chain-Castro *et al*., 1998; Venkateswarlu *et al*., 2000). Reasons for lesser involvement of women than men in MDCA as reported by farmers were related to toughness of the spraying job for women, women were regarded as more susceptible to pesticide poisoning than men, fear of extending risks of exposure to babies or foetuses in pregnant women and inability of husbands to handle houses once wives fall sick after application of agrochemicals. Based on socio-cultural norms existing in the study area, the daily domestic chores like cooking, washing, cleaning the house and taking care of children are traditionally done by women. Although the gender distribution for tasks reduced chances of agrochemical exposure to women, further anthropological studies are needed in order to identify and clarify the actual reasons for observed gender discriminated practices and if such practices deny women's access to income accrued through sale of agricultural products.

Although most of the necessary protective devices for agrochemical applications were available in the market, and some farmers were able to buy them, climatic conditions were reported to limit their usability (Dinham and Malik, 2003). Other studies in Ghana reported that the reason for not wearing protective gears during pesticides applications, even if they were available, was to avoid body heat stress (Fianko *et al.,* 2011). Most of the farmers perceived that side effects associated with exposure to agrochemicals were of short duration that ended when they recovered from clinical manifestations. These findings suggest the need for manufacturers to consider protective devices conducive for tropical climate, and also the need to educate farmers on the long term consequences of pesticide exposure (Anon, 1996). Studies conducted by the International Labour Organization (ILO) suggest that pesticide indiscriminate causes 14% of occupational injuries in agriculture and, in some countries, fatalities of up to 10% has been reported (Codex, 2005).

CONCLUSION

In the current study the health hazards associated with the use of agrochemicals were contributed by several factors. They included illiteracy, lack of hazard awareness, lack and failure to use protective gears. Use of agrochemicals without instructions and in non-original containers, reuse of agrochemical containers, storage of agrochemicals in risk premises and lack of enforcement of regulations related to their distribution were also reported as health hazards. Findings from this study have demonstrated the need for interventions targeting key stakeholders, including farmers, extension service providers, and regulatory bodies regarding the observed mishandling practices of agrochemicals. Environmental as well as human and animal health hazards associated with such practices; and the need to adhere to regulations guiding the legitimate sell, distribution, and handling of agrochemicals in Tanzania are additional important issues that require interventions. From this assessment three foci and target groups for interventions are identified: training of farmers on good agricultural practices, strengthening agricultural extension services, and reinforcing regulatory services.

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