The International POPs Elimination Project

Fostering Active and Effective Civil Society Participation in Preparation for Implementation of the Stockholm Convention

Water and Sediments Analysis in Vikuge POPs Contaminated Site in Tanzania

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About the International POPs Elimination Project

On May 1, 2004, the International POPs Elimination Network (IPEN http://www.ipen.org) began a global NGO project called the International POPs Elimination Project (IPEP) in partnership with the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Program (UNEP). The Global Environment Facility (GEF) provided core funding for the project.

IPEP has three principal objectives:

- Encourage and enable NGOs in 40 developing and transitional countries to engage in activities that provide concrete and immediate contributions to country efforts in preparing for the implementation of the Stockholm Convention;
- Enhance the skills and knowledge of NGOs to help build their capacity as effective stakeholders in the Convention implementation process;
- Help establish regional and national NGO coordination and capacity in all regions of the world in support of longer-term efforts to achieve chemical safety.

IPEP will support preparation of reports on country situation, hotspots, policy briefs, and regional activities. Three principal types of activities will be supported by IPEP: participation in the National Implementation Plan, training and awareness workshops, and public information and awareness campaigns.

For more information, please see http://www.ipen.org

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ACRONYMS AND ABBREVIATIONS

AGENDA	AGENDA for Environment and Responsible Development
ATSDR	Agency for Toxic Substances and Disease Registry
CMWG	Community Monitoring Working Group of IPEN
o,p'- DDD	1,1-dichloro-2-(2-chlorophenyl)-2-(4-chlorophenyl) ethane
o,p'- DDE	1,1-dichloro-2-(2-chlorophenyl)-2-(4-chlorophenyl) ethene
o,p'- DDT	1,1,1-trichloro-2-(2-chlorophenyl)-2-(4-chlorophenyl) ethane
p,p'- DDD	1,1-dichloro-2,2-bis (4-chlorophenyl) ethane
p,p'- DDE	1,1-dichloro-2,2-bis (4-chlorophenyl) ethene
p,p'- DDT	1,1,1-trichloro-2,2-bis (4-chlorophenyl) ethane
DDT	Dichlorodiphenyltrichloroethane
∑DDT	Total DDT (*p,p'*- and *o,p'*- DDT + DDE + DDD)
DAWASCO	Dar es Salaam Water Supply Company
EECD	European Economic Community Directive
ENVIROCARE	Environment, Human Rights Care and Gender Organization
EU	European Union
FAO	Food and Agriculture Organization
GCLA	Government Chemist Laboratory Agency
GEF	Global Environment Facility
α-HCH	1α, 2α, 3β, 4α, 5β, 6β-hexachlorocyclohexane or α-1,2,3,4,5,6-hexachlorocyclohexane
β-HCH	1α, 2β, 3α, 4β, 5α, 6β-hexachlorocyclohexane or, β-1,2,3,4,5,6-hexachlorocyclohexane
γ-HCH	1α, 2α, 3β, 4α, 5α, 6β-hexachlorocyclohexane or, γ-1,2,3,4,5,6-hexachlorocyclohexane
δ-HCH	1α, 2α, 3α, 4β, 5α, 6β-hexachlorocyclohexane or, δ-1,2,3,4,5,6-hexachlorocyclohexane
ε-HCH	ε-1,2,3,4,5,6-hexachlorocyclohexane
HCHs	Hexachlorocyclohexanes
∑HCH	α-HCH + β-HCH + γ-HCH + δ-HCH + ε-HCH

IPEN	International POPs Elimination Network
IPEP	International POPs Elimination Project
MAFS	Ministry of Agriculture and Food Security
NEMC	National Environment Management Council
NGOs	Non Governmental Organisation
POPs	Persistent Organic Pollutants
SIDA	Swedish International Development Agency
TBS	Tanzania Bureau of Standards
TPRI	Tropical Pesticides Research Institute
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization

EXECUTIVE SUMMARY

The project aim was to test for existence and levels of POPs near Vikuge contaminated site through sampling common food source (eggs in separate report) and common water sources linked to a specific source of organochlorine pesticides with particular reference to Dichlorodiphenyltrichloroethane (DDT). Water and sediment samples were collected from three different ponds namely Namtipwa, Kwa Ndende and Vikuge which are located 1200m north, 2800m north-east and 1000m south-west kilometres respectively from the Vikuge contaminated site. Several ponds and local wells have been constructed within the seasonal streams, wetlands and on the banks of ponds and have been the only reliable source of water for the Vikuge Village. Water from those wells is used for domestic, livestock and irrigation purposes.

The pesticides and metabolites detected on water and sediments samples analysed were α-HCH, β-HCH, γ-HCH, δHCH, *o,p'*-DDT, *p,p'*-DDT, *p,p'*-DDE and *p,p'*-DDD. The concentrations of ∑DDT in water samples were 500ng/l, 1800 ng/l and 1400ng/l for Vikuge, Namtipwa and Kwa ndende ponds respectively. Water from Vikuge pond has ∑DDT content lower than the Tanzanian limit (1000 ng/l) (TBS, 1999) and the WHO limit (2000 ng/l) (WHO, 1996) while water samples from Natipwa and Kwa Ndende ponds are higher than Tanzania limits while lower than the WHO limit. The concentrations of ∑DDT in sediment samples were 5300 ng/g, 8100 ng/g and 8500ng/g for Vikuge, Namtipwa and Kwa Ndende ponds respectively, were higher than the Netherlands limit(1000 ng/g)(Marco, 2004). The HCHs detected in water and sediments samples were α-HCH, β-HCH, γ-HCH and δ HCH. Water samples from all ponds had higher concentrations of ∑HCHs than the European Union limit for surface water (100 ng/l) (EECD, 1976). Concentrations of ∑HCHs in water samples were 2600ng/l, 3100ng/l and 700ng/l for Vikuge, Namtipwa and Kwa Ndende ponds respectively. Concentrations of lindane in water samples from Vikuge and Kwa Ndende were below than the Tanzanian limit (3000 ng/l) (TBS, 1999) while that from Namtipwa was higher. Concentrations of ∑HCHs in water samples from Vikuge and Namtipwa were higher than the WHO limit (2000 ng/l) while that from Kwa Ndende was lower (WHO, 1996). The HCHs detected in sediments samples were α-HCH, β-HCH, γ-HCH and δ HCH. The highest concentrations of HCHs and metabolites ranged from 1100 – 3000 ng/l α HCH, 200 – 1500 ng/l for β HCH, 500 – 2300 ng/l for γ HCH and 0 – 2100 ng/l for δ HCH.

In conclusion, the level of contamination of water and sediments by pesticides and metabolites appears to be related to point source contamination by pesticide residues from the heavily contaminated Vikuge site. The findings suggest potential high risks and concerns to public health.

Therefore, it is recommended that there is an urgent need for remedial actions to address public health concerns of the affected community. More POPs monitoring and awareness-raising to understand the magnitude of the problem and to develop sustainable measures to minimize further effects.

1.0 INTRODUCTION

Pesticides have played significant roles in agriculture and public health programmes (WHO, 1990). However, the increase in pesticide use has caused great concerns over the presence of pesticides in the environment and the threat they may pose to wildlife and humans (Plimmer, 2001). Their use and abuse can lead to serious food quality problems, fish kills, reproductive failure of birds, illnesses in people, and reduction of beneficial species, such as pollinating insects. Usually this is the result of misapplication, improper storage, or disposal of pesticides (Norstrom and Muir, 1994).

POPs Pesticides have been proved to be severe environmental contaminants and are included in a broad range of organic micro pollutants that have ecological impacts (Oxynos *et al*., 1989). These organochlorine pesticides have a wide range of both acute and chronic health effects, including cancer, neurological damage, and birth defects. Many organochlorines are also suspected endocrine disruptors (WHO, 1990). The hazardous nature of these compounds is due to their toxicity, high chemical and biological stability, and high degree of lipophilicity. High stability and lipophilicity give them a characteristic to bioaccumulate along the food chain involving a wide range of trophic levels (Wania and Mackay, 1996).

The IPEN egg sampling study in Tanzania also involved water and sediments analysis. The study was carried out between January and April 2005 and its aim was to analyse for existence and levels of POPs near Vikuge contaminated site. The samples were analysed for specific POPs contamination levels in a common food source (eggs in separate report) and common water sources linked to a specific source of organochlorine pesticides with particular reference to DDT. There are many people living in the vicinity of the contaminated site and most of them rely mainly on groundwater from shallow wells as their primary source of domestic water supply. The pesticide-contaminated sites are a major environmental and public health concern that needs special attention.

The study identifies types and levels of contamination and recommends a way forward for the government and the community to avoid further damage caused by POPs chemicals in the area of study as well as other areas in the country.

1.1 BACKGROUND

In 1986 the Government of Tanzania through the Ministry of Agriculture and Food Security (MAFS) received a quantity of pesticides in different forms (liquid, powder, pellets and sprays) as a ‘donation’ from the Government of Greece. The consignment was in poor condition and in damaged packages. Besides, most of the labels on containers were written in Greek, strongly indicating that the pesticides were intended for use locally in Greece and no preparation was made to receive such large consignment due to the fact that the government of Tanzania did not expect such a large amount of pesticides (AGENDA, 2004; Kishimba and Mihale, 2004).

The stock received was about 600 metric tonnes when it arrived at Vikuge hay farm and was stored under a temporary shed in open air. The Ministry of Agriculture distributed about 400 tonnes for use particularly in southern regions of Tanzania for tsetse fly control. It is estimated that about 200 metric tonnes remained at the site.

The shed that was used for temporary storage collapsed in 1993, therefore pesticides were exposed to direct sunlight, rain and other climatic variations (Elfvendahl *et al*., 2004). Improper storage or disposal of pesticides and containers has led to pesticides being spilled in the environment, which has therefore resulted in contamination of the environment including soil, water, plants and animals (FAO, 1998). Such spillage or dispersion has caused serious soil, surface water as well as ground water contamination. When soil and water are contaminated, crops, livestock and other organisms may become affected; and when they are consumed by human beings, health risks may occur (FAO, 2000).

In 1996, with external assistance of the Government of Sweden (SIDA), a stable store was built, under supervision of the National Environment Management Council (NEMC). All stocks were then stored in that store, which is situated just 20 meters away from the original storage shed.

Even though the pesticides were collected and stored, the old storage site was found to be heavily contaminated about five years later. In 2001 high levels of pesticide residues including DDTs and HCHs were detected in soil. The levels of ∑DDT and ∑HCH were up to 282,000 mg/kg dry weight and 63,400 mg/kg dry weight, respectively (Elfvendahl *et al*., 2004; Kishimba and Mihale, 2004). This study was undertaken specifically to determine the pesticide residues in pond water and sediments near the Vikuge village which are used as source of water for domestic purposes.

AGENDA selected the Vikuge village, which is located near the Vikuge contaminated site, which contains mainly DDT, as a case study. This report will explain the legacy of obsolete stocks, the status of contaminated sites and therefore will aid in the struggle for a cleaner, healthier and more sustainable environment. It will help in the development of the NIP and plan for decontamination after the implementation of the Africa Stockpiles Programme (ASP).

1.2 OBJECTIVE OF THE STUDY

The overall objective of the study was to establish type and levels of POPs contamination on a common food (eggs) and water bodies near the Vikuge (POPs) contaminated site.

The specific objective of this study was to determine levels of contamination in the environment, particularly common water sources and sediments linked to a specific source of organochlorine pesticides storage with particular reference to DDT.

2.0 METHODOLOGY OF THE STUDY

2.1 INTRODUCTION

This section covers the methodology used in conducting the study. It explains what the study entailed, approaches, scope of work and the tools used for the study.

2.2. SCOPE OF THE WORK

AGENDA participated in the IPEN egg sampling study which included water and sediments analysis for POPs residue on the areas near Vikuge contaminated site specifically POPs contamination levels in common water sources linked to a specific source of organochlorine pesticides storage with particular reference to DDT.

The following activities were executed during the fieldwork so as to meet the objectives of the study: -

i) Consultation with all the concerned community members. Local leaders and local government officials as well as other key informants such as elders, farmers, women, youths and influential people, who live in the Vikuge village.

ii) Identification and selection of water and sediment sampling locations. Six water samples and six sediments samples were collected and tested for POPs pesticides analysis at the Chemistry department at the University of Dar es Salaam. Sampling was conducted on three different ponds namely Namtipwa, Kwa Ndende and Vikuge of which local people have hand-dug local wells for domestic water on the banks of the ponds.

2.3. INITIAL WORK

2.3.1 Selecting Team for Field Work

Fieldwork involved two researchers from AGENDA. These researchers have been involved in various field surveys and have experience in environmental management and planning, environmental assessment, environmental engineering and socio-economic analysis.

2.3.2 Tools

The study tools such as sampling procedure, questionnaire and checklist were developed after conducting adequate review of existing literature. The questionnaire was designed such that it contained only close-ended questions.

2.4 FIELD WORK

The following activities were executed during the fieldwork so as to meet the objectives of the study: -

2.4.1. Consultations

A number of interviews and focus group discussions with concerned community members at the Vikuge village were conducted.

2.4..2. Water and Sediment Sampling

Water and sediment samples were collected in May 2005. Six samples of water (two from each pond) and six samples of sediments (two from each pond) were collected from three different ponds namely Namtipwa, Kwa Ndende and Vikuge which are located 1200m north, 2800m north-east and 1000m south-west kilometres, respectively from the Vikuge contaminated site. Sampling and storage procedure of the samples followed Government Chemist Laboratory Agency water and sediment sampling and storing procedures (GCLA, 2002). The samples were analysed by using GC-MS spectrometry equipment analysis procedures in the Chemistry department at the University of Dar es salaam.

3.0 STUDY FINDINGS

3.1. PHYSICAL DESCRIPTION OF SITE

3.1.1 Physical Description of Site

Vikuge contaminated site is located between latitudes 6° 45’ and 6° 50’ South of the Equator and longitudes 38° 50’ and 38° 55’ East. It is located about 35 miles (56 km) North East of Dar es Salaam City. The old store and new store covers an area of approximately 100m^2. Administratively, the study site is located within the Vikuge Village, Soga Ward, Kibaha District, in the Coast Region, Tanzania.

3.1.2 Topography

The Vikuge area where the contaminated site is situated on a broad upland with an altitude of 129 - 152m above sea level with undulating terrain. The contaminated site area is almost a flatland gently sloping towards the north where Vikuge village is situated. The contaminated site is situated at the higher point as compared to the Vikuge village.

3.1.3 Surrounding Water Supplies

There are no major rivers in the area. However, there are signs of a seasonal watercourse running from the south, across the site, towards the lower areas in the north towards the Vikuge village. It seemed that surface water run-off from the contaminated site follows that seasonal water course and discharge its water into the Namtipwa seasonal stream. The Namtipwa stream is used for agricultural activities as well as for washing and domestic use. The Namtipwa stream eventually joins the Ruvu River on the north.

Vikuge Village entirely depends on water from seasonal streams and wetlands, boreholes and local wells even though there is tap water which is not reliable. Tap water is available at the State Farm (hay production centre) and to the nearby villages including Vikuge village supplied by Dar es Salaam Water Supply Company (DAWASCO). Tap water is a bit expensive for the villagers such that it is mainly used for drinking. Therefore, the villagers mostly get water from unprotected sources such as hand dug wells and seasonal streams, and thus suspected to be a source of water borne diseases.

3.1.3.1. Seasonal Streams, Ponds and Wetlands

There are three seasonal streams located near Vikuge village and those are known as Kwa Ndende, Namtipwa and Vikuge stream. Water from those streams is mainly used for irrigations especially for vegetables and for domestic and livestock purposes.

The Namtipwa stream, which is located on the northern side of the Vikuge village, receives storm water directly from the high lands of the State Farm. This was verified by the presence of the rainwater terrain, which cut across the middle of the contaminated site. Large amounts of the pesticides might be washed away downstream to Namtipwa stream that connects to the Ruvu River, which supplies water for the Dar es Salaam City. Other ponds, which are located near the contaminated site, despite being sources of water for agriculture and domestic use, are also used for fishing.

3.1.3.2. Boreholes and Local Wells

There are 4 boreholes in Vikuge Village to provide the villagers with clean and safe water. Unfortunately water quality of one borehole, which was constructed on the edge of Namtipwa stream, was found undesirable for domestic and animal use and the borehole was sealed. The reasons for closing that borehole were not revealed to the study team. However, with that unknown reason of closure of the borehole, the Villagers dug some few local wells along side the closed borehole for domestic use.

Several ponds and local wells have been constructed within the seasonal streams and have been the only reliable source of water for the Vikuge Village. Water from those wells is used for domestic, livestock and irrigation purposes.

3.1.4 Surrounding Plant and Wildlife

Vikuge area is characterised with scanty vegetation, which consist mainly of bush thicket mixed with annual herbs, thorns, deciduous shrubs, grasses, and some few evergreen exotic trees. Before the consignment was brought at Vikuge site, most of the indigenous trees and vegetations for a long time were already affected from the pressure of human activities such as grazing, farming and fuel wood collection.

Villagers reported existence of good number of rabbit, rats, snakes, lizards and different types of flying insects near and within the Vikuge village before the consignment was dumped on the area. However, after the consignment was bought at the area, big animals ran away and other small insects and worms were victims of the pesticides. Furthermore, on the area of the Vikuge village, there were observed a small number of different types insects flying and reported existence of small number of rats, snakes and lizards. The number increases with distance from the contaminated site.

3.2. Water and Sediments Analysis

The pesticides and metabolites detected in water and sediments samples analysed were α-HCH, β-HCH, γ-HCH, δHCH, *o,p'*-DDT, *p,p'*-DDT, *p,p'*-DDE and *p,p'*-DDD. DDT, DDE and DDD have been linked to many deleterious chronic effects in human and animals including endocrine disruption, changes of liver enzymes, increased occurrence of liver tumours, reproductive defects, breast cancer and egg-shell thinning (WHO, 1990; ATSDR, 1994).

3.2.1. Distribution of DDT and Metabolites in Water Samples

DDTs (*p,p*'-DDT and *o,p*'-DDT) and their metabolites (*p,p*'-DDD and *p,p*'-DDE) were found in water and sediments samples (Table 1). The highest concentrations of DDTs and metabolites ranged from 300 – 1100 ng/l for p,p-DDT and 200 – 1000 ng/l for *o,p*'-DDT. The concentrations of DDD were higher than those of DDE in all samples. This can be explained by the fact that, on top of being a metabolite of DDT under anaerobic degradation, DDD is toxic enough to be used as a pesticide on its own, in which case it is known as rothane. On the other hand, the only source of DDE is through aerobic degradation of DDT, in which DDE is the main product (Tomlin, 2000).

The concentrations of *p,p'*-DDT were below the European limit for surface water (25,000 ng/l) (EECD, 1976). The concentrations of *p,p*'-DDT in all water samples, were about 3 to 11 times greater than the European Union (EU) maximum limit (100 ng/l) (EU, 1998), indicating a potential risk and concern to the aquatic environment and public health. The concentrations of *o,p'*-DDT in water samples were about 2 to 11 times higher than the EU limit (100 ng//l) and *p,p'*-DDE in water samples were about 15 times higher than the EU limit (100 ng//l). The concentrations of ∑DDT in water samples were 500ng/l, 1800 ng/l and 1400ng/l for Vikuge, Namtipwa and Kwa Ndende ponds respectively. Water from Vikuge pond has ∑DDT content lower than the Tanzanian limit (1000 ng/l) (TBS, 1999) and the WHO limit (2000 ng/l) (WHO, 1996) while water samples from Natipwa and Kwa Ndende ponds are higher than Tanzania limits while lower than the WHO limit.

3.2.2. Distribution of DDT and Metabolites in Sediments Samples

The DDT residues detected in sediments were *p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDD and *p,p*'-DDE. It can be observed in the samples collected and analysed that sediment samples showed high levels of DDT and its metabolites. The highest concentrations of DDTs and metabolites ranged from 1400 – 2900 ng/l for p,p-DDT, 1500 – 2900 ng/l for o, p-DDT, 1600 - 3700 ng/l for p, p DDD and 0 – 1500 ng/l for p, p-DDE. The concentrations of ∑DDT in sediment samples were 5300 ng/l, 8100 ng/l and 8500ng/l for Vikuge, Namtipwa and Kwa Ndende ponds respectively. All sediments samples had higher content of ∑DDT than the Netherlands limit (1000 ng/l) (Marco, 2004).

3.2.3. Distribution of Hexachlorocyclohexanes and Metabolites in Water Samples

The HCHs detected in water and sediments samples were α-HCH, β-HCH, γ-HCH and δ HCH. HCH isomers disrupt the immune function by affecting white blood cells, adversely affecting kidneys, affecting calcium metabolism, and are carcinogenic to some animals (ATSDR, 1999).

It can be observed that the water had high levels of HCHs. The highest concentrations of HCHs ranged from 500 – 1800 ng/l for α HCH, 0 – 600ng/l for β HCH and 200 – 1000ng/l for γ HCH. The ratios of α-HCH to γ-HCH (lindane) can be used to trace the amount of active ingredients and transport pathway of the HCHs. This ratio should be 4–7 for technical HCH, and nearly zero for technical lindane (Iwata *et al*., 1995). γ-HCH was the dominant HCH-isomer in water samples.

Water samples from all ponds had higher concentrations of ∑HCHs than the European Union limit for surface water (100 ng/l) (EECD, 1976). Concentrations of ∑HCHs in water samples were 2600ng/l, 3100ng/l and 700ng/l for Vikuge, Namtipwa and Kwa Ndende ponds respectively. Concentration of water samples from Vikuge and Kwa Ndende were below than the Tanzanian limit (3000 ng/l) (TBS, 1999) while that from Namtipwa was higher. Water samples from Vikuge and Namtipwa were higher than the WHO limit (2000 ng/l) while that from Kwa Ndende was below than the limit (WHO, 1996).

3.2.4. Distribution of and HCHs and Metabolites in Sediments Samples

The HCHs detected in sediments samples were α-HCH, β-HCH, γ-HCH and δ HCH. It can be observed in the samples analysed that sediment showed high levels of HCHs and its metabolites. The highest concentrations of HCHs and metabolites on dry weight basis ranged from 1100 – 3000 ng/l α HCH, 200 – 1500 ng/l for β HCH, 500 – 2300 ng/l for γ HCH and 0 – 2100 ng/l for δ HCH.

3.3 Discussion of the Results

It has been observed from the results that water and sediments samples from different sampling points had concentrations of lindane (HCHs) and DDT compounds which were higher and others lower than the Tanzanian, Netherlands, EU and WHO maximum limits. The findings indicate a potential risk and concern to the aquatic environment and public health as well due to the fact that the presence and eventual exposure to these POPs compounds even at low levels will inevitably build up in the food chain. It can be concluded that, even though some of the results are under the limits, it does not mean that things are safe at Vikuge village and therefore precautionary measures should be taken immediately to safeguard health of the people, living organisms and the environment in general.

4.0. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

The level of contamination of water and sediments by pesticides and metabolites appears to be related to a point source contamination by pesticide residues from the heavily contaminated Vikuge site. The findings indicate potential risks and concerns to public health. The present study suggests that there is active transfer of these compounds from the source to various sites through runoff and volatilisation followed by atmospheric deposition. The detected compounds are generally resistant to attack by abiotic or biotic agents in the environment, and thus most of these compounds persist for long periods in the environment and often exhibit half-lives of many years, for example up to 16 years for *p,p'*-DDT. The variability is due to the range of different conditions that occur in the environment. They have a tendency to adsorb to sediments and bioaccumulate in aquatic organisms.

The findings signify that the population around the site are likely affected by the contaminated water and food they consume from the polluted sources. This calls for an urgent need for health monitoring and safeguarding to avoid further damage and effects from the same.

4.2. RECOMMENDATIONS

1. There is an urgent need for remedial actions to address public health concerns of the affected community.
2. There is an urgent need for helping the affected individuals living near the sites by providing medical services, alternative and safe sources of water.
3. There is a need for more POPs monitoring and awareness to avoid further use of the water sources as well as plans for preventive measures.
4. Community's accessibility to information and data on POPs and U-POPs releases from all potential sources and their detrimental effects. The information should be translated into a language they can understand.
5. Address the problem of decontamination of the highly contaminated site.
6. Mark the contaminated area as a hazardous area, prohibiting activities that will lead to further damage especially to children.

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ANNEX

Table 1. Water and Sediments Sample Results

Sampling pond (ng/l)	Code	αHCH	βHCH	γHCH	δHCH	opDDT	ppDDT	ppDDE	ppDDD	∑HCH	∑DDT
Vikuge	**Water**	1800	400	400	0	200	300	0	0	2600	500
	Sediments	3000	1500	2300	0	1500	1400	200	2200	6800	5300
Namtipwa	**Water**	1500	600	1000	0	1000	800	0	0	3100	1800
	Sediments	2100	600	800	200	1500	2900	0	3700	3700	8100
Kwa Ndende	**Water**	500	0	200	0	300	1100	0	0	700	1400
	Sediments	1100	200	500	2100	2900	2500	1500	1600	3900	8500

All results are in ng/l

NB:

EU limit for *p,p'*-DDT in water samples is 100 ng/l
EU limit for *o,p'*-DDT in water samples is 100 ng/l
EU limit for *p,p'*-DDE in water samples is 100 ng/l
Tanzanian limit for ∑DDT in Water samples is 1000 ng/l
WHO limit for ∑DDT in Water samples is 2000 ng/l
EU limit for ∑HCHs in surface water is 100 ng/l
Tanzanian limit for ∑HCHs in water samples is 3000 ng/l
WHO limit for ∑HCHs in water samples is 2000 ng/l
Netherlands limit for ∑DDT in sediment samples is 1000 ng/l

SAMPLE ANALYSIS GRAPHS

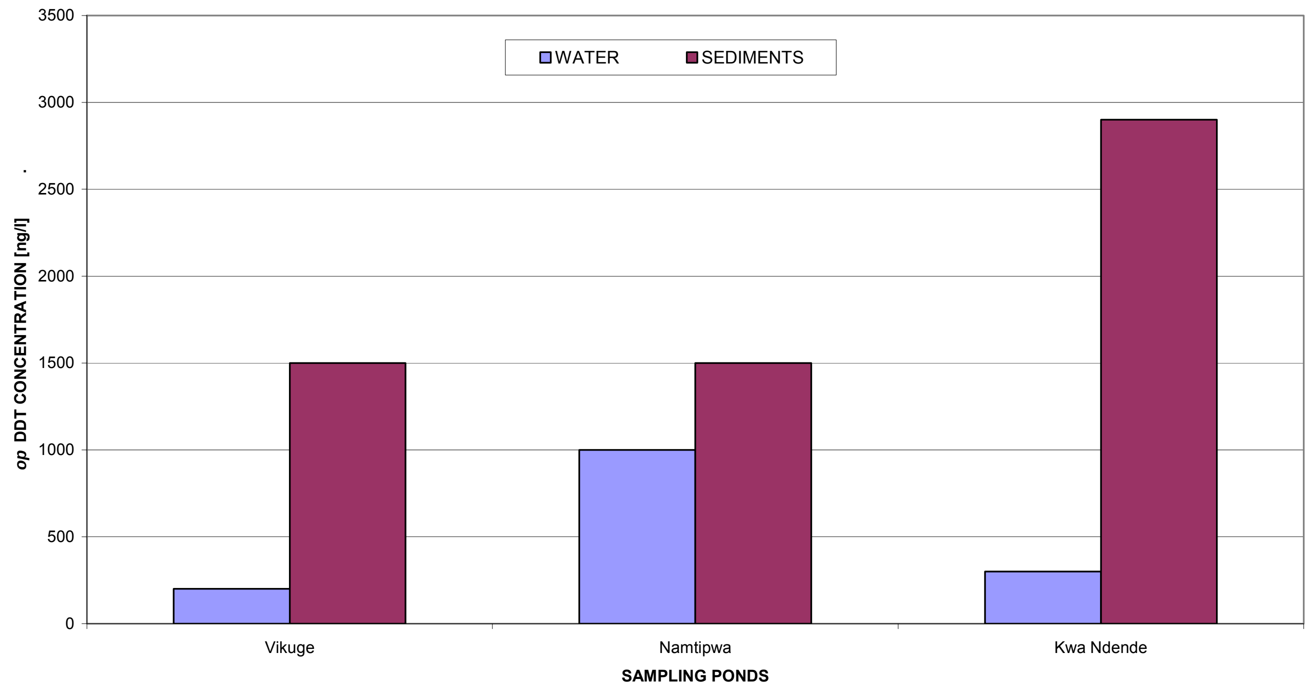

Fig G1. Graph of *o,p'*- DDT metabolites

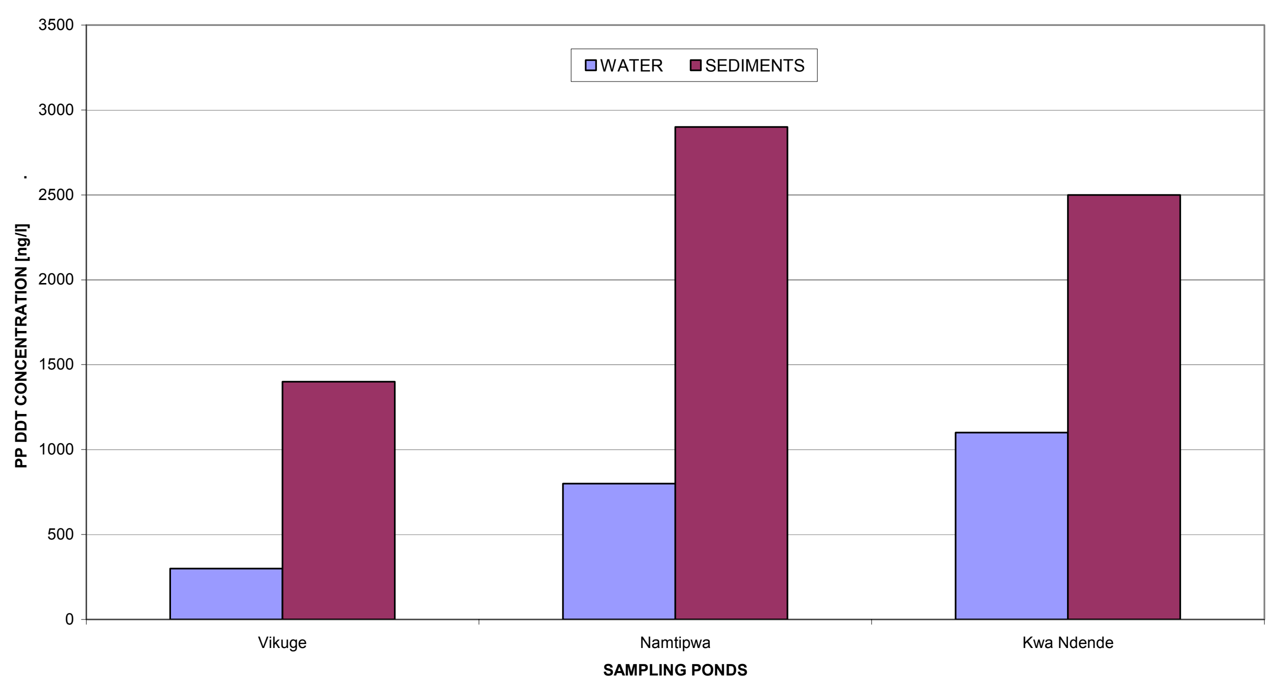

Fig G2. Graph of *p,p'*- DDT metabolites

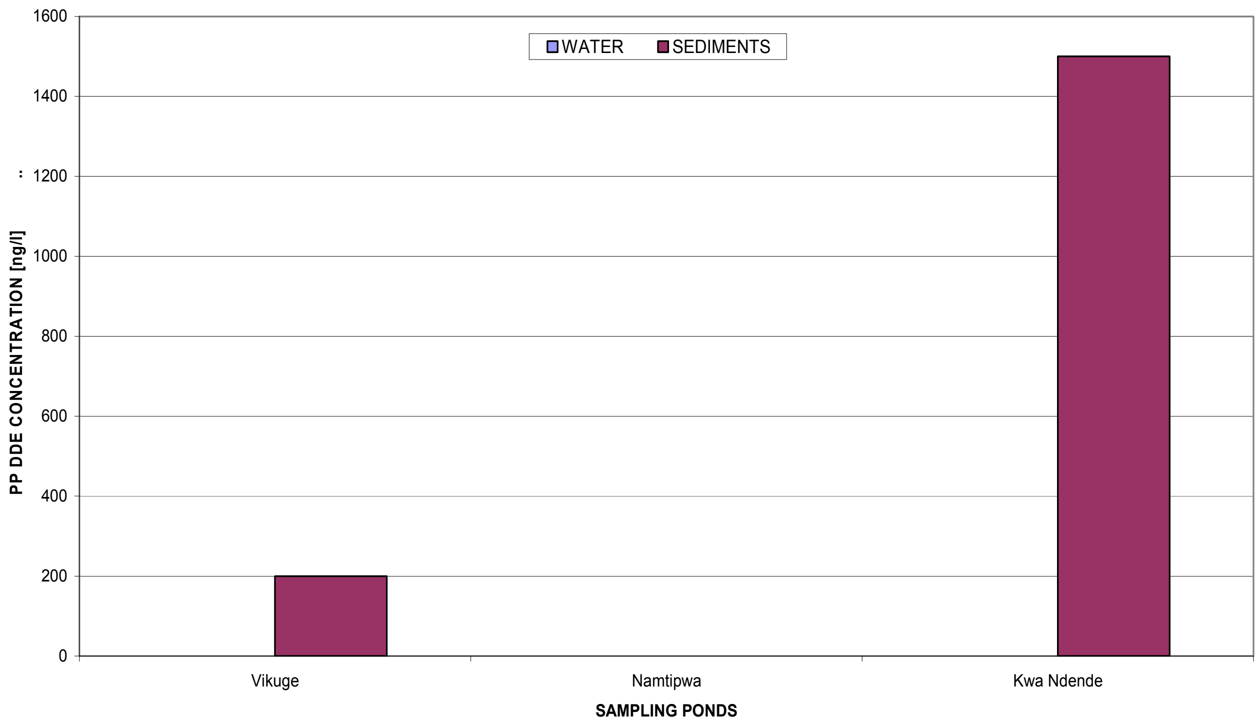

Fig G3. Graph of *p,p'*- DDE metabolites

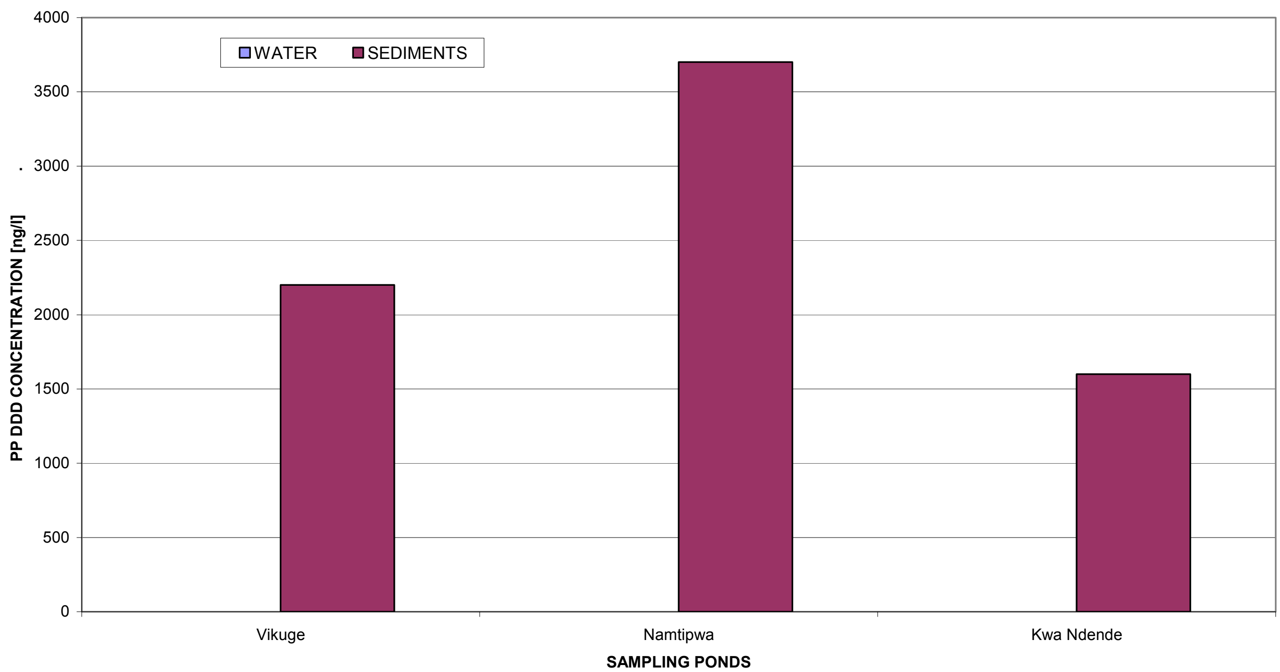

Fig G4. Graph of *p,p'*- DDD metabolites

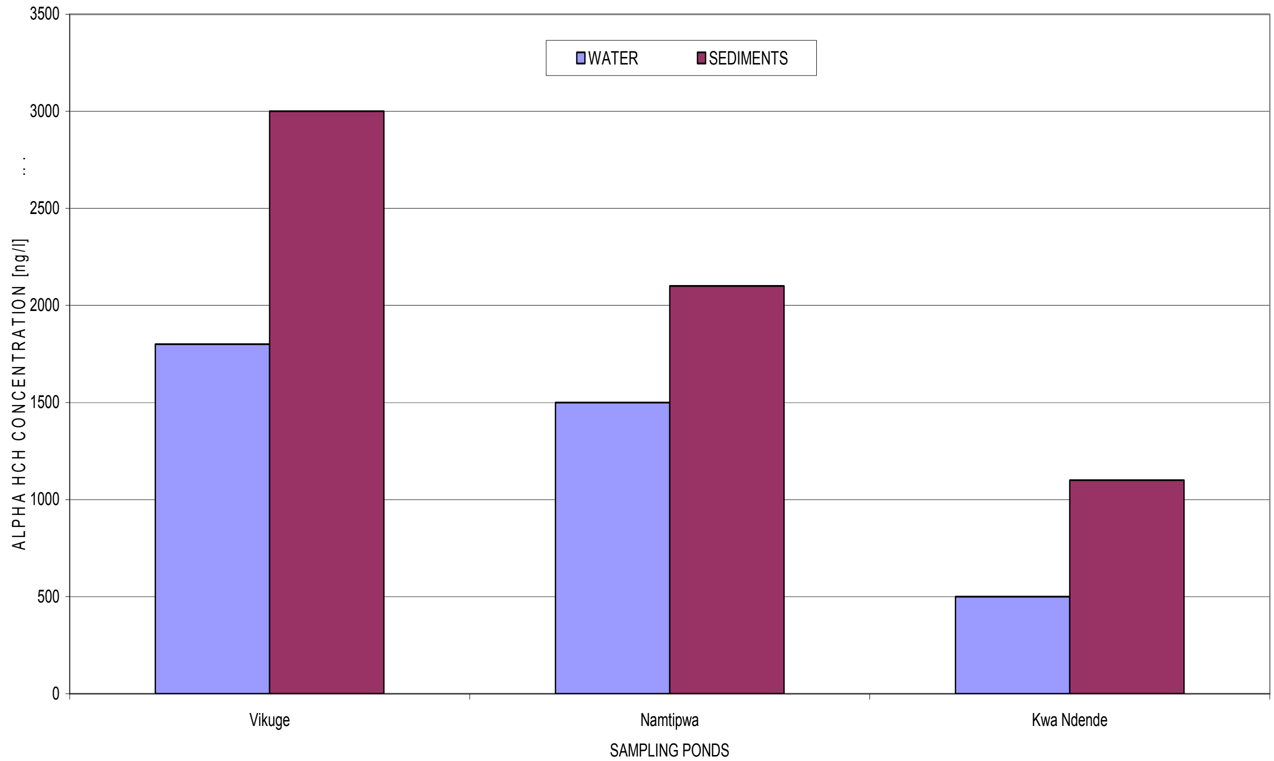

Fig G5. Graph of α-HCH metabolites

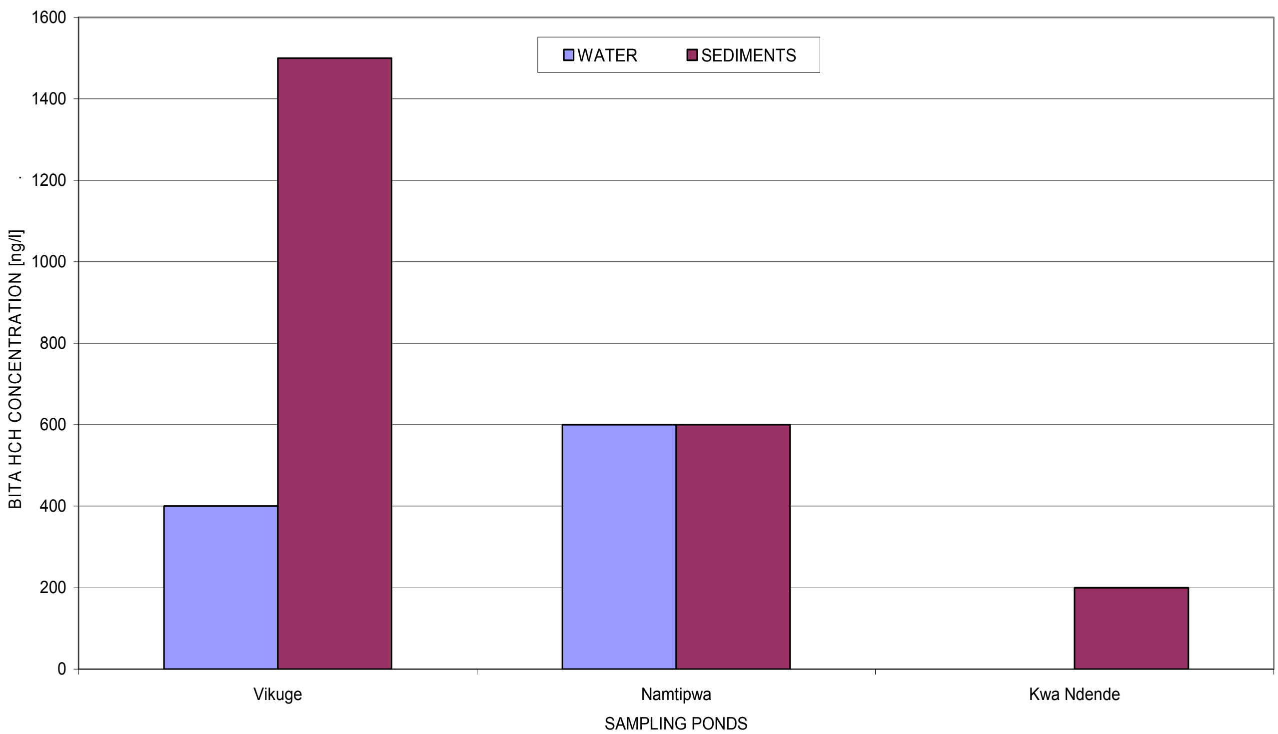

Fig G6. Graph of β-HCH metabolites

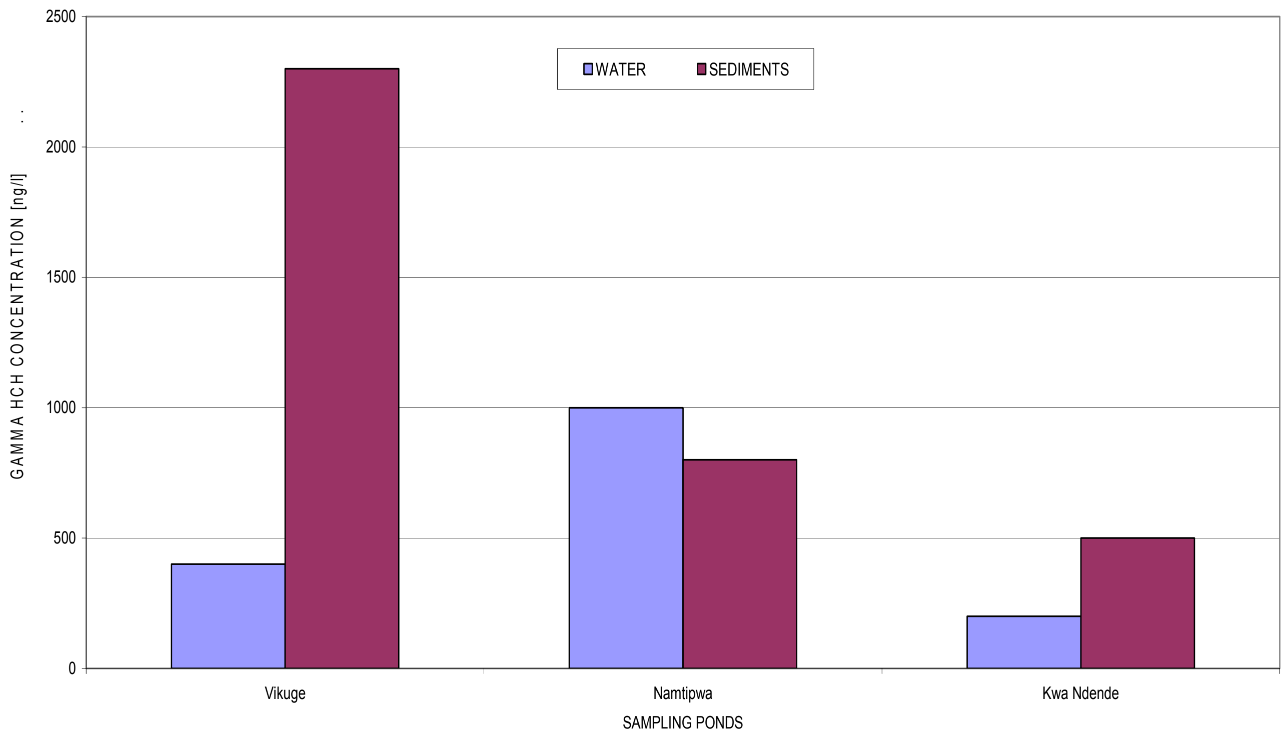

Fig G7. Graph of γ-HCH metabolites

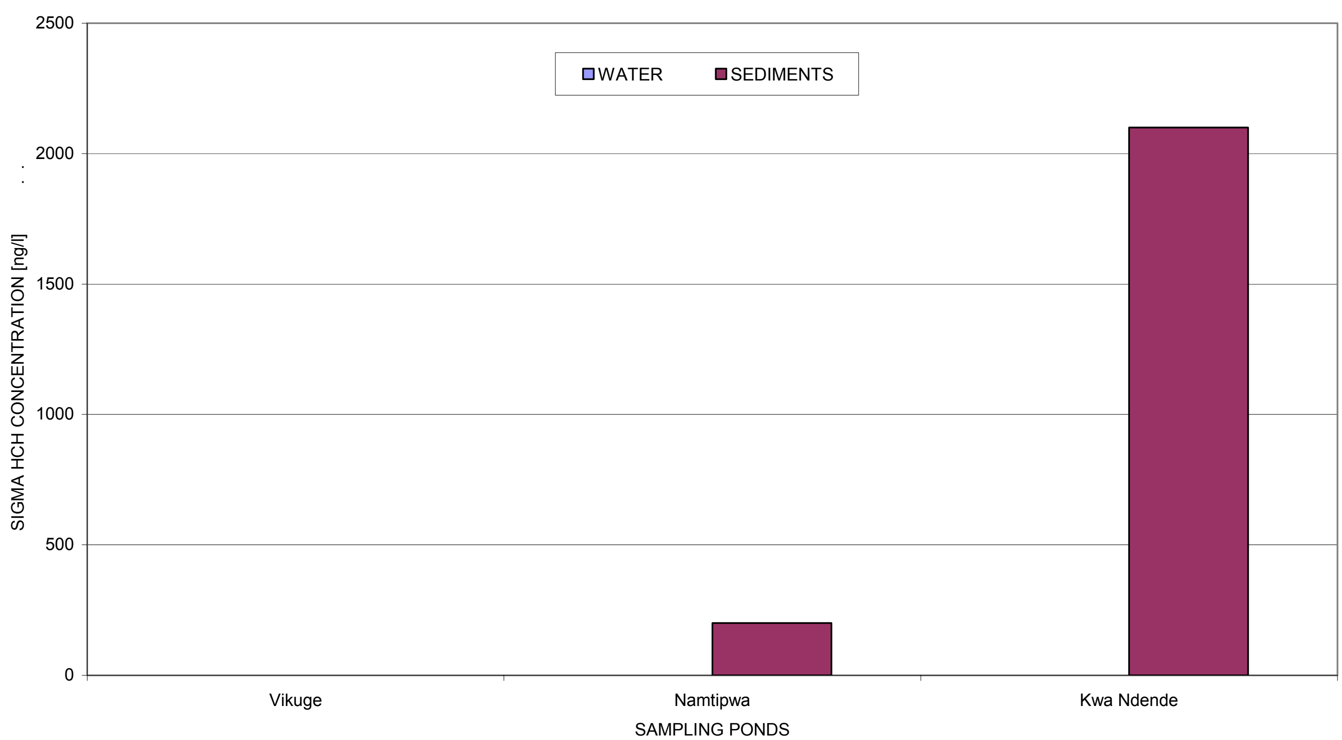

Fig G8. Graph of δ-HCH metabolites

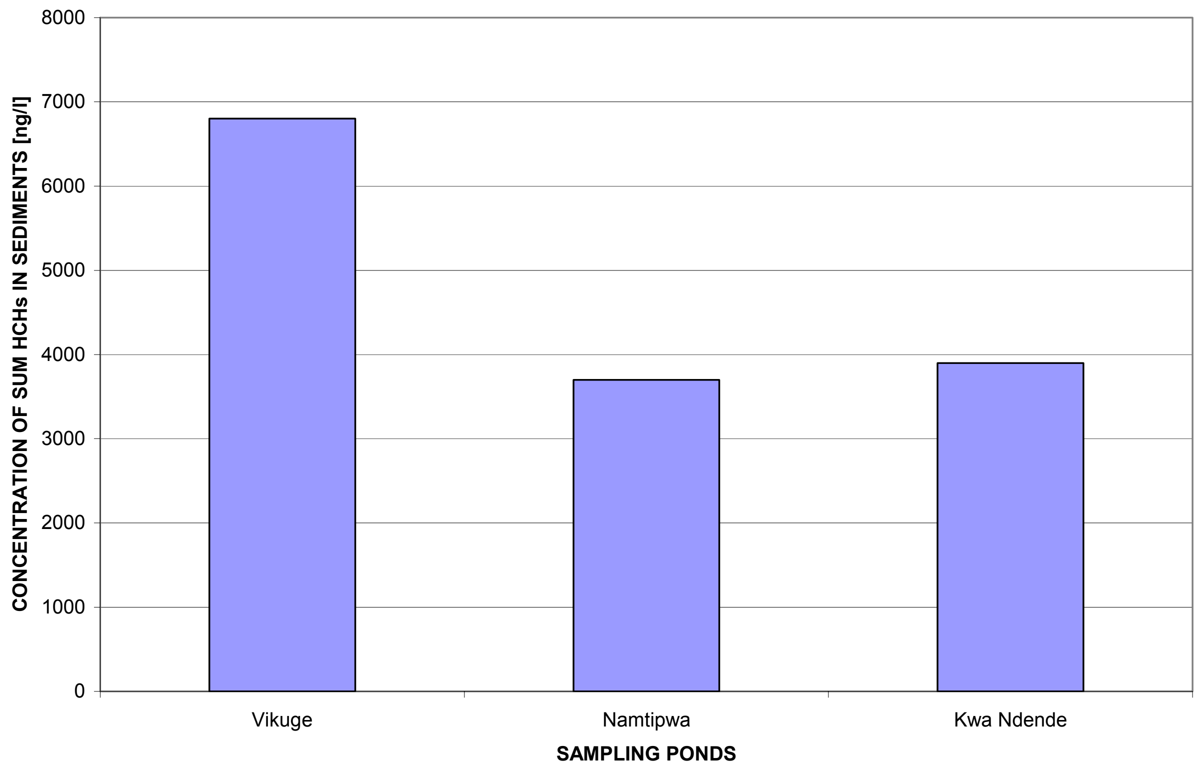

Fig G9. Graph of ∑HCHs in Sediments samples

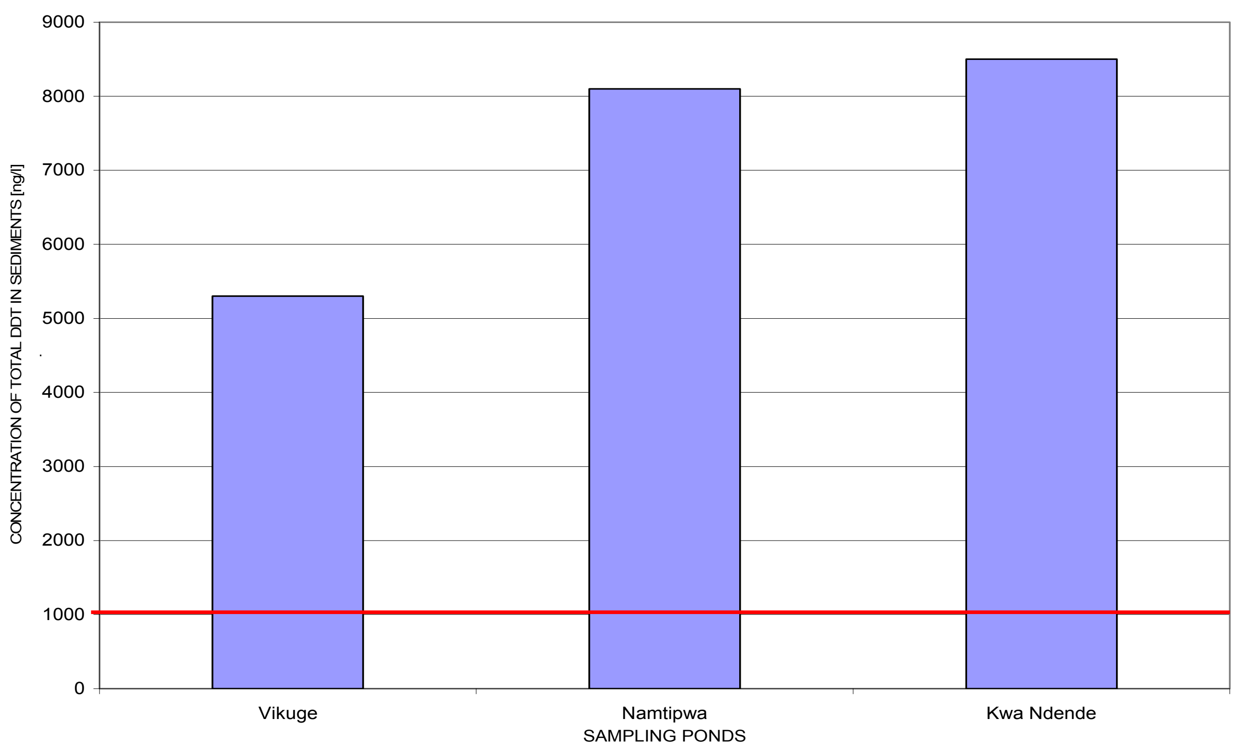

Fig G10. Graph of ∑DDT in Sediments samples

Note: Red line shows Netherlands limit for ∑ DDT in sediments samples is 1000 ng/l

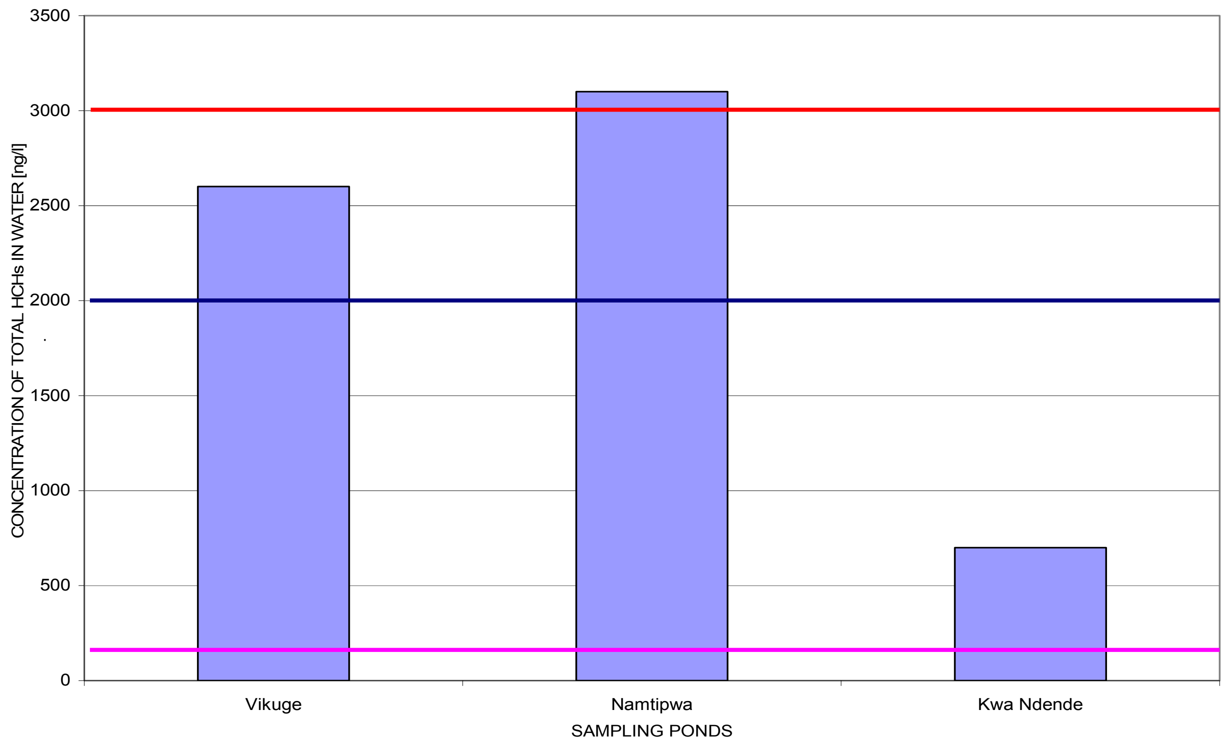

Fig G11. Graph of ∑HCHs in water samples with Tanzania, WHO and EU limits

Note: Red line shows Tanzanian limit for ∑HCHs in water samples is 3000 ng/l
Blue line shows WHO limit for ∑HCHs in water sample is 2000 ng/l
Pink line shows EU limit for ∑HCHs in surface water is 100 ng/l

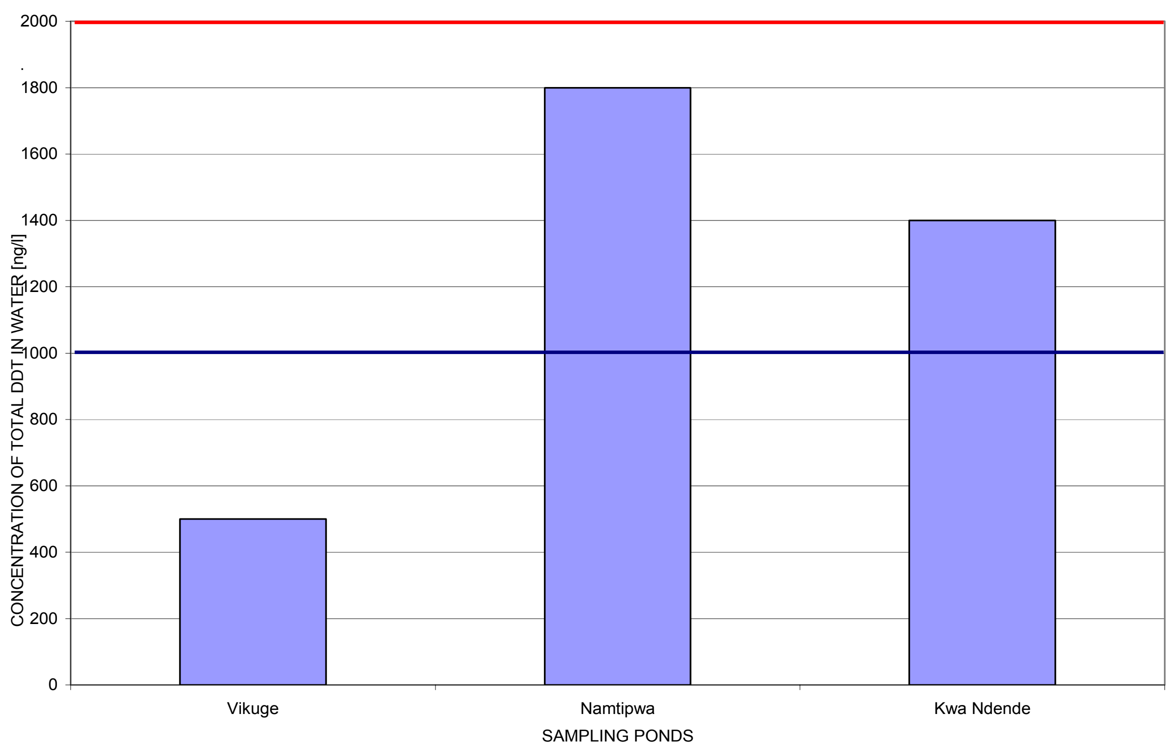

Fig G12. Graph of ∑DDT in water samples with WHO and Tanzania limits

Note: Red line shows WHO limit for ∑DDT in Water sample is 2000 ng/l

Blue line shows Tanzanian limit for ∑DDT in Water samples is 1000 ng/l

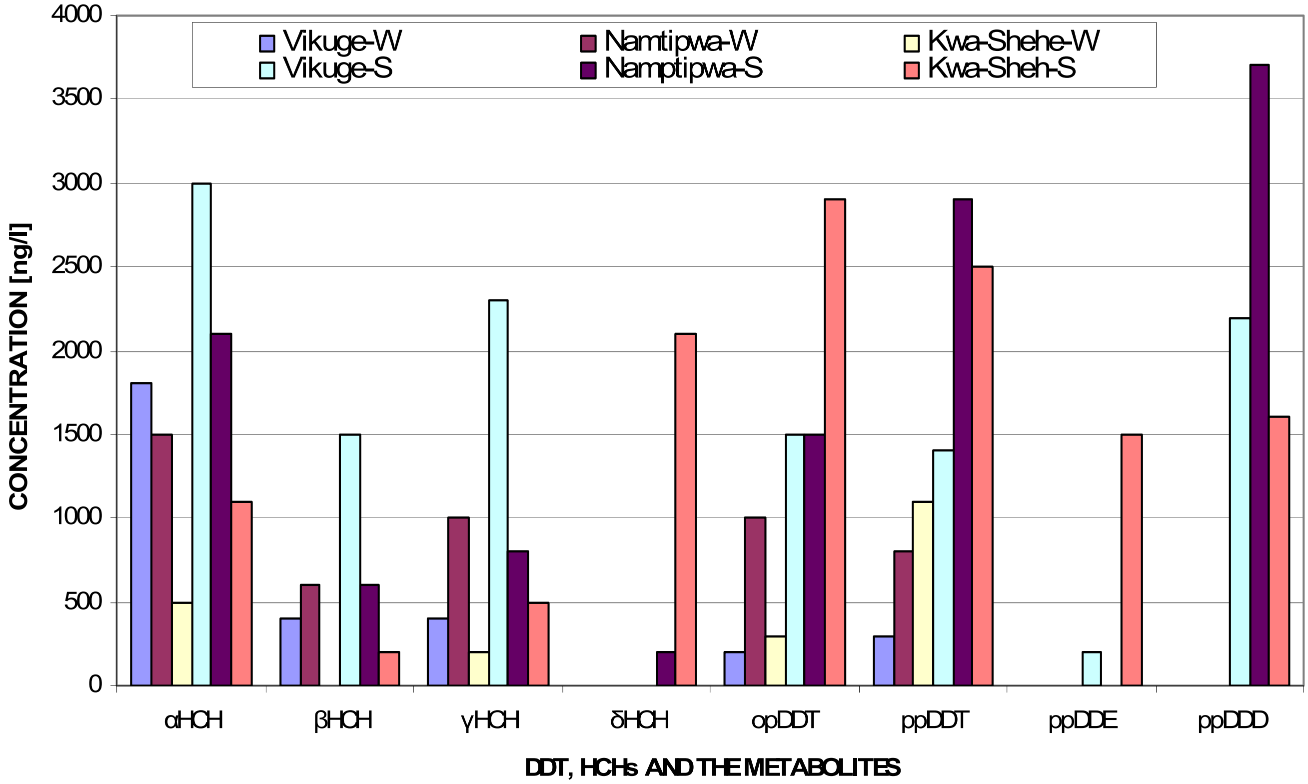

Fig G13. Graph of overall analysis of pesticides and its metabolites

MAPS

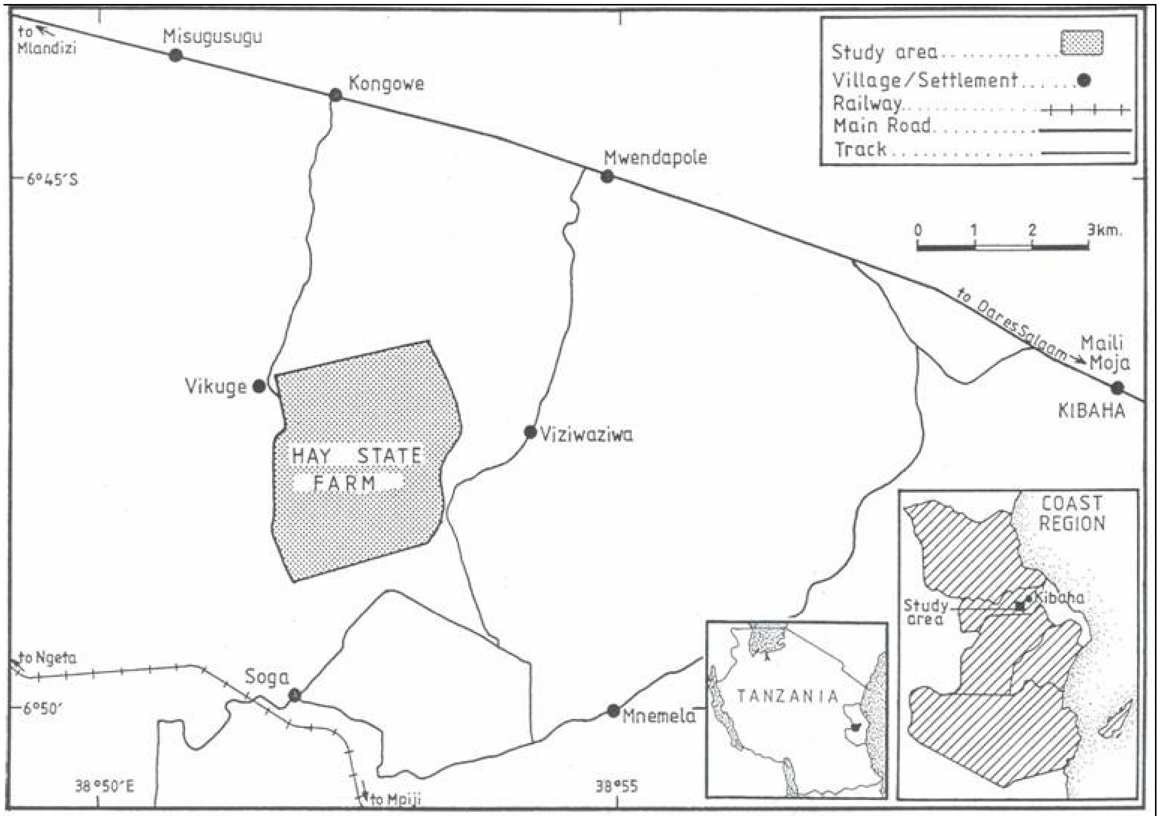

Fig. M1. Map showing the Vikuge site location

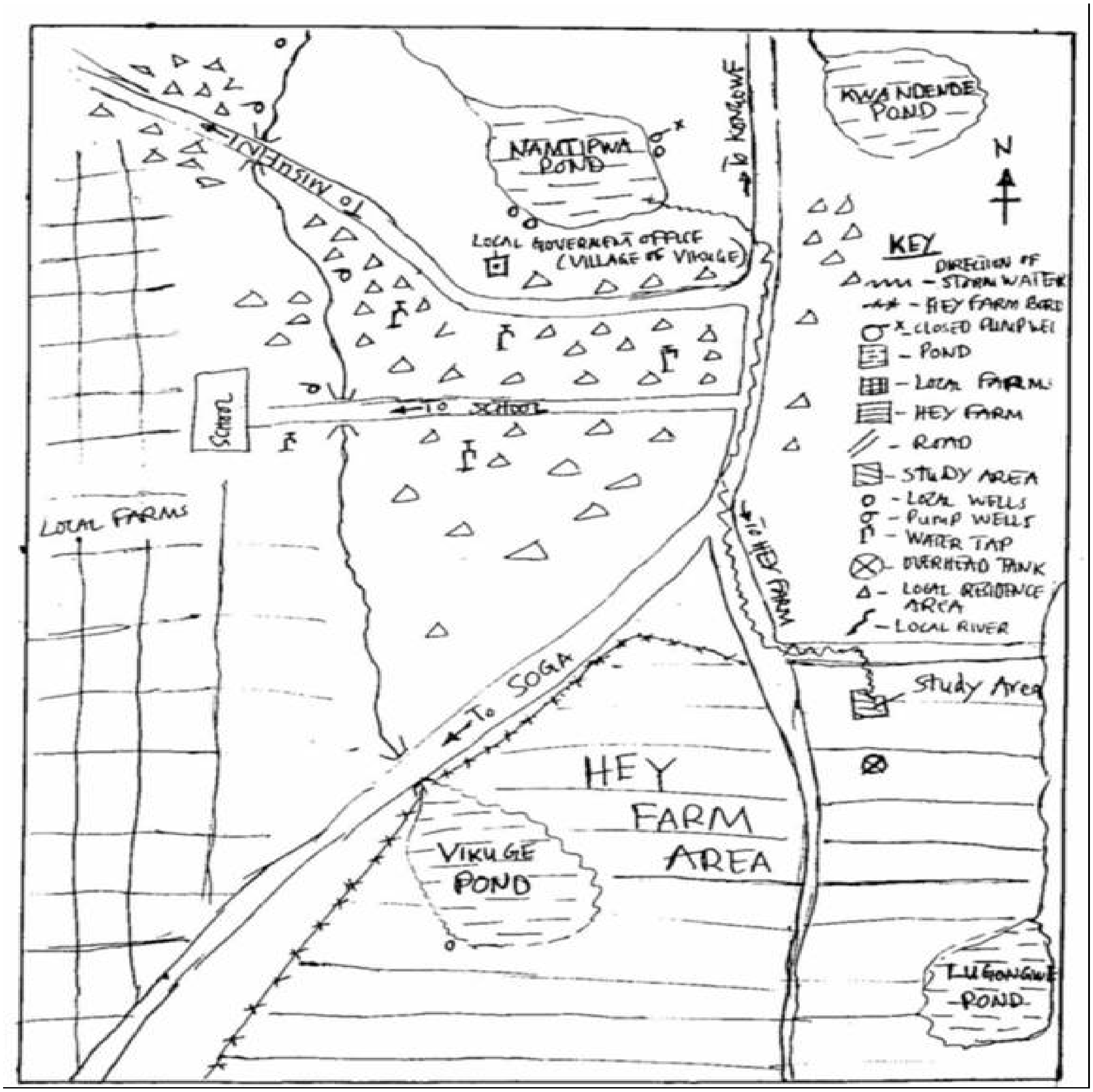

Fig M2. Resource map of Vikuge Area

PLATES

Plate P1. Hand dug local well along Namtipwa stream

Plate P2. Water sampling along Namtipwa stream

Plate P3. Children playing on the small pond along Namtipwa stream

Plate P4. Clothes are sun-dried near the closed well along the Namtipwa stream

Plate P5. Clothes are sun-dried near the Namtipwa pond

Plate P6. Catfish caught along Namtipwa stream