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Analysis of Organochlorine Residues in a Farmland Soil near Lake Zeway, Ethiopia

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Abstract

Intensive use of pesticides in natural environments have become a major threat for public health and many organisms. Pesticides enter the environment via various mechanisms and disrupt the normal function of organisms in water and soil. Pesticides enter air and soil through spray drift, fallout and irrigation water contaminated with pesticides. Pesticides present in soil affect microbial population and their proper function in the soil environment. Microorganisms in soil are essential for maintenance of soil structure, organic matter mineralization, making nutrients available for plants and to metabolize and degrade a lot of pollutants and pesticides in the soil. However, long-term application of pesticides causes irreversible changes in their population which in turn brings about decline in soil fertility and crop productivity. The presence of pesticide residues in the air also enter soil and water by means of precipitation and eventually end up in human and animal bodies through the food, water and air they use. Thus water, soil and air pollution by pesticides result in a fatal health effect in humans, animals and many other organisms. The purpose of this study was to evaluate pesticide residues in a farm land soil and the methodology employed was site selection, sample collection and preparation and transport of the samples for laboratory analysis. The analytical result also indicated the presence of DDT and its metabolite (DDD) in two of the soil samples and virgin land soil.

Keywords: Organochlorine; Persistent; Residues; Bio-accumulation; Environmental hazard

Abbreviations: DDT: Dichlorodiphenyl Tetrahloroethane; DDD: Dichlorodiphenyl Dichloroethyne; DDE Dichlorodiphenyl Dichloroethane; BHC: Benzene Hexachloride; ND: None Detectable

Introduction

Agriculture is readily associated with the use of different chemical inputs. Different classes of pesticides are used in managing different groups of pests to maximize crop production and meet the demands for higher supplies of food for human population. However, pesticide contamination has become a matter of environmental concern because of the adverse effects on soil microorganisms, which in turn affects soil quality. The continuous use of pesticides in agriculture, flowers, forests and their breakdown products accumulate in soil environment causing a potential risk on environment and non-target organisms including man. Pesticides enter the soil during spray on food crops, vegetables and flower treatment and precipitation from the air contaminated with pesticides. Organochlorine pesticides which are water insoluble have high half-life in soil and their persistent or breakdown in soil depend on the chemical and biological properties of the soil. Organochlorine pesticides strongly stick on organic matter and clay particles making them less mobile, bioavailable and less accessible to microbial degradation and thus are more persistent in the soil environment [1,2]. Soils include millions of microorganisms that play a key role in helping plants utilize soil nutrients needed to grow and flourish. Microorganisms help soil to store water and nutrients, regulate water flow, and filter pollutants. But pesticides, though beneficial, contaminate soil disrupting the normal functions of microorganisms in the soil environment [3,4]. The balance equilibrium among microorganisms and soil, which is essential for mineralization of organic matter and to make nutrients available for plants is highly affected by the presence of pesticides in soil. The potential of microorganisms to metabolize and degrade pesticides in soil is incapacitated by pesticides present in the soil. Pesticides accumulate in soil environment via spray drift, wet and dry deposition from air and contaminated water used for irrigation. Soil contaminated with pesticides result in ill-effects on public health, animals and soil microorganisms that play a major role in improving soil fertility and agricultural crop yield [5,6].

Material and Method

Site description

The study is conducted at a farmland near Lake Ziway, the fourth largest Lake of Ethiopia. It is located 160 kilometers south of Addis Ababa, bordered by Oromia and the Southern Nations, Nationalities and Peoples regional states. The lake is the only single source of water supply for small- and large-scale irrigation farms enabling area community to produce different food crops and vegetables. Vegetables produced by this irrigation water is distributed to many market centers in the country and the life of many people directly or indirectly depend on selling vegetables besides to crop production. Local communities solely depend on the lake water for drinking water supply and their exposure to pesticide impacts from the contaminated soil may be high and threatening. The irrigated farmland which is dependent on the lake water is surrounded by many development activities (floriculture) that can discharge untreated pesticide waste into the lake water via different paths. The soil in the irrigated farmland is possibly contaminated by pesticides of different nature through spray, drainage and the lake water abstracted for open and closed farm irrigation. The lake water as a source for irrigation and domestic water supply for local people can expose the community to threatening pesticide risks. Thus, the soil in the irrigated farmland and the blanket of air around are a likely potential to cause unavoidable health and environmental damages (Figure 1).

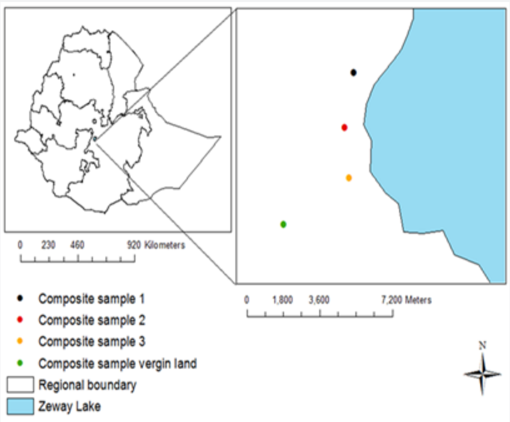

Figure 1: Soil sample sites on farm land around Zeway Lake.

Method

Three soil samples were collected from three farm land sites near the lake. The sample collected from each site were composite to represent the farm condition. One soil sample was also collected from virgin land as control. The samples were air dried, grinded and passed through 2mm mesh being ready for subsequent analysis. Organochlorine pesticide residues in soil samples were extracted using Soxhlet Extraction (EPA METHOD 3540C). The exposed PUF Filters were cut into pieces and extracted in soxhlet extractor for the soil sample. A 10g of soil sample was placed into a beaker containing 10g anhydrous sodium sulfate and mixed thoroughly. The sample mixture was transferred to an extraction thimble and placed in a Soxhlet extractor. The mixture was extracted with 150ml of acetone: n-hexane (1:1 v/v) at 50°C for 20hrs. The extract was filtered and concentrated to 2ml using vacuum rotary evaporator and nitrogen gas bubble. Each of the raw concentrated extract was then redissolved in 10ml hexane. Column containing 3gm of activated silica gel and 3gm sodium sulfate was conditioned with hexane. The analyte was passed through pre-conditioned column. The sample (analyte) which was trapped in the column was eluted with 80ml of hexane. The collected elute was then concentrated to 5ml by blowing nitrogen gas and transferred to 10ml volumetric flask and diluted to the mark with hexane and dichloromethane respectively. The samples were transferred to GC/MS auto sampler vial for analysis. The Multi-residue organochlorine standard containing 23 pesticides was injected to GC/MS and calibrated. The NIS software library was used in screening mode for qualitative identification of the chemical where SIM mode was used for quantification. By calibrating the GCMS with standard containing the 13 standards for quality control, a recovery extraction was made for HCB (Figure 2).

Figure 2: Water abstracted from Lake Zeway for irrigation.

Result

Table 1: Laboratory analysis result of organochlorine pesticides in soil ppb.

Sample Matrices	DDT and its Metabolites around Lake Zeway Farm Land Soil Samples in ppb			
	DDT	DDD	DDE	DDT sum
S1	28.39	79.61	ND	108
S2	21.11	103.7	ND	124.81
S3	19.06	ND	ND	19.06
Virgin Land ($4)	14.09	54,55	ND	68.64

As can be seen in the table 1 above, four soil samples from three farms and one virgin land site was obtained for the analysis of organochlorine pesticides. The organochlorine pesticides analyzed include DDT and its breakdown products (DDD, DDE), benzene hexachloride, heptachlor, heptachlor epoxide, aldrin, and α-chlordane. All soil samples did not show many of

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the organochlorine pesticides except DDT and its metabolite DDD. But all soil samples analyzed indicate to contain DDT and its breakdown product DDD. DDD was found in two sites of the farm land and the virgin land in concentrations of 79.61, 103.7 and 54.55ppb respectively. The amount of DDD in the soil sample from the virgin land is relatively small as compared to the amount obtained in the soil samples from the farm land sites. However, all soil samples analyzed indicate to contain DDT and its magnitude being 28.39, 21.11, 19.06 and 14.09 ppb respectively. Though both organochlorine pesticides (DDD and DDT) are present in farm land soil samples, the value of DDD is much higher than the values for DDT indicating rapid decomposition of DDT as a result of bacterial and solar actions. The value of DDD in the virgin land (54.55ppb) is higher than the value for DDT (14.09ppb).

Discussion

The laboratory test of soil samples from three farmlands and one virgin land showed the presence of only two organochlorine pesticides, DDT and its metabolite, DDD. The remaining organochlorine pesticides such as DDE, benzene hexachloride, heptachlor, and Aldrin were below the detection limit. One sample from the farmland did not also show the presence of DDD while two soil samples from the farm land and one sample from the uncultivated land (S4) indicate 78.61, 103.7 and 54.55ppb values for DDD respectively. But all four soil samples analyzed showed 28.39, 21.11, 19.06ppb for DDT in the farmland and 14.09ppb in the virgin land. The value of DDD in the soil samples is higher compared to the magnitude of DDT in the same soil samples. DDE, which is also the bacterial degradation product of DDT is absent in all soil samples analyzed and this may be contributed to its presence below the detection limit or due to some analytical errors. Generally, DDT and its degradation product, DDD are present in all soil samples obtained from the farmland and uncultivated land indicating the long-term application of DDT on farm land and its decomposition by soil microorganisms into DDD. The presence of such chemical agents in the soil can be transferred into human and animal bodies via dermal contact, ingestion with food and water or inhalation thereby causing an irreversible health effect by interfering with the normal nerve impulses. DDT and its by-product DDD are slightly to moderately toxic to birds, fish, aquatic animals and soil microorganisms affecting heart and brain. Though DDT is abandoned from use in Ethiopia except for malaria eradication, its high half-life in soil, illegal use by farmers, wind deposit from far distances and poor practices are among the many reasons for the presence of DDT and its metabolites in the soil samples analyzed.

Conclusion

All soil samples analyzed showed the presence of total DDT; 108,124.81, 19.06 and 68.64 respectively. The ratio of undecomposed DDT /DDD is in the ratio of 0.2 to 0.35 indicating about 80 % to 65% of active DDT being decomposed into DDD by soil microorganisms. These chemicals reach to animals and humans by magnifying themselves through the food web and cause several damages to health. The presence of DDT and its metabolite in the soil samples indicate the long-term application of pesticides on agriculture and its persistent in the soil environment. Regardless of the source, these pesticide residues in the soil are responsible to cause hazard on public health and the environment.

Recommendation

The continuous and unsafe practice of pesticides on agriculture is reason enough for the accumulation of such chemical agents in the farm land soil. To alleviate the effects associated with such pesticide residues, proper selection and control of illegal pesticide importation together with public awareness are crucial with respect to Ethiopian context.

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