

## **Abstract**

Pesticides are indispensable to increase agricultural production and control human and animal diseases. Due to these benefits pesticides have been used for more than half a century worldwide. Though the use of pesticides is important, their residues remain in different environmental compartments (water, food, soil, air) and may impact human health and environment negatively. Due to their intrinsic capacity to cause a risk to human and other organisms, pesticides are under strict regulations starting from their synthesis and formulations over the mixing and loading of the spray mixture, the application and the food production and consumption.

Due to the fact that Ethiopia's population is continuously increasing, which puts pressure on agriculture, agricultural intensification with high demands for fertilizers, pesticides and other agrochemicals is becoming high. Unlike most developed countries, the pesticide regulation in the country is not well enforced, which may aggravate the contamination of the environment and consumer products that could cause human exposure. As a result, addressing human exposure and consumer risk assessment in Ethiopia is vital to safeguard the population. The main intention of this study was therefore, to undertake human exposure studies and consumer risk assessments based on the level of consumption and the presence of different pesticides residues in commonly consumed food items, water and khat.

Different food items were collected from markets located in southwestern Ethiopia. Water samples were collected from untreated and treated water sources in Jimma zone and Addis Ababa. Food items were analyzed using the QuEChERS (Quick, Easy, Effective, Rugged and Safe) method, while liquid-solid and liquid-liquid extraction methods were used to analyze the water. The determination of the pesticides was done using gas chromatography with electron capture detector (GC-ECD) and liquid chromatography with double mass spectrometer detector (LC-MS/MS). Human exposure to pesticides was determined using deterministic and probabilistic exposure calculation methods by considering pesticide residues and consumption data.

In this work different pesticides with a concentration ranging from 0.011 to 1.115 mg/kg were detected in staple food items (teff, coffee beans, red pepper) including non-authorized pesticides such as DDT more than one third of the residues were above the maximum residue limit (MRL). This may be the result due to different reasons, such as illegal application of pesticides. Consumers

are exposed to these pesticides through their food. Therefore, frequent monitoring of these and other pesticides is of paramount importance to ensure food safety.

Maize is a commonly consumed food item for different groups of people in the community including infants to which it is given as complementary diet. DDT was detected in these maize samples above the corresponding MRL. The presence of DDT in infants' food may have a risk to this vulnerable group. Health risk estimation revealed that, the mean and the high (97.5 percentile) consumer estimated daily intake (EDI) of total DDT for actual consumers were above the provisional tolerable daily intake (PTDI). For the total infant population (including non-consumer infants) only the 97.5 percentile was above the PTDI. This is an indication for chronic health problems for the infants. The risk may be severe in infants because of their physiological makeup is not yet matured to metabolize and excrete this chemical hazards.

Pesticides are detected in water sources as most of the water bodies are located in the vicinity of agricultural fields. The pesticides applied for agricultural and public health purposes can directly or indirectly reach the surface water as environmental drift, diffusion or runoff. Water samples from water sources in Jimma zone and Addis Ababa were collected and analyzed for the presence of pesticides. Analytical results reveal the presence of organophosphate pesticides (diazinon, malathion and pirimiphos methyl), fungicide (fenpropimorph), and herbicide (2,4-D) in water from source up to the point of consumption (community taps). A high concentration of these pesticides was detected in the untreated water sources (well, river, spring and stream water). In the streams passing through the agricultural fields the concentration was higher than in the other water bodies. The estimated daily intake (EDI) of these pesticides was calculated and compared with the health based reference values namely, the acceptable daily intake (ADI) and acute reference dose (ARfD). From the findings, all the pesticides detected had no acute risk ( $EDI < ARfD$ ), while diazinon for Jimma population and diazinon and fenpropimorph for Addis Ababa population showed a chronic risk ( $EDI > ADI$ ). The exposure and risk may be much more severe since water is used not only for drinking but also for cooking of other foods. This suggests a need for a frequent monitoring of pesticides in different water sources in Ethiopia.

Pesticides may not only contaminate water and conventionally edible food items, but also other consumer products such as khat. Khat is consumed in many parts of East Africa and Arabian countries. This stimulant plant is consumed by about half the population of the Ethiopian

communities. From khat samples collected in Southwestern Ethiopia, DDT and its metabolites were detected at different magnitudes. The exposure assessment from khat consumption indicated that, the EDI of DDT is less than the health based reference value, however that does not guarantee 100% safety as the plant is consumed fresh.

Food processing has a significant effect for the reduction of pesticide residues in food. For example, household coffee and teff processing shows a reduction in pesticide residues. The household processing of coffee beans decreased the residue up to 99.8% while, backing of teff injera up to 90.2%. In both cases, the processing factor (PF) was less than one, which indicates a pesticide residues reduction due to the applied food processing. In countries like Ethiopia which do not have strong and enforced pesticides regulations and proper pesticide monitoring programs, food processing may be one solution to minimize risks associated with pesticides.

In general, Ethiopians may be at a larger risk due to pesticide exposure from food and other various sources. Integrated pesticide management and law enforcement need to be effectively applied in Ethiopia to minimize risks and to get optimum pesticide benefits.