Theme: Sustainable use of land resources to alleviate poverty in the new millennium
STUDIES ON THE INFLUENCES OF LANDUSE ON SOIL AND WATER RESOURCES IN THIKA DISTRICT, KENYA

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ABSTRACT

In the last three decades a decline has been observed in water and soil resources resulting from non-point or point source pollution. Landuse patterns may contribute to pollutants flowing into water or soil within a certain region. This study was carried out to investigate the influence of different landuse patterns on water and soil quality. Data collection was done from three major landuse zones namely coffee, horticultural and Thika urban zone during the period September 1999 to June 2000. Twenty-one water samples were collected per each site along Chania River and levels of heavy metals were determined using x-ray fluorescence. In addition, twelve representative soil samples were collected per site along the Chania River and levels of heavy metals in soils were also determined. Heavy metal levels in water were found to be higher in the Thika urban site (Blue post) compared to coffee zone site (Egaad Estate) located upstream. However, the levels are still below the drinking water standards. With increase in the use of agrochemical inputs and soil erosion the levels of heavy metals in water or soil may increase in the future.

Soil samples reflected higher levels of heavy metals than water but still within allowed limits. Statistical analysis further revealed a correlation between land use and heavy metals in river water as well as from the soil. Iron and zinc were found to be higher compared to other metals. Chania River receives agrochemical wastes from horticultural and coffee farms as it flows from Egaad coffee estate to Bluepost. Therefore the levels of heavy metals at downstream site at Thika Blue post was found to be higher than levels at upstream site at Egaad coffee estate. For example zinc in river water was 2.9ppb and 1.6ppb at Egaad coffee estate and Thika Blue Post respectively. The allowed limits for zinc in drinking water standards set by Kenya Bureau of Standards is 5.0Oppm. To prevent increase of heavy metals in soil and water, there is need for proper landuse planning such as reduction of agrochemical inputs especially from the horticultural farms. Incorporating integrated pesticide control, agricultural extension or enhancing soil conservation methods such as afforestation would further reduce heavy metal pollution.

Key Words: Chania River, landuse, water quality, heavy metals, environmental pollution

INTRODUCTION

Landuse planning is increasingly becoming an area of concern in environmental issues. With the world human population growth increasing at a rate of 1.5-2% there is need for proper landuse planning to prevent water pollution as well as soil degradation. The Thika River drains an area with intensive agricultural activities consequently water may deteriorate without proper protection. River Thika and it’s tributary Chania are a source of water to the local population around Thika district and the largely populated Nairobi city. Fresh water resources in Kenya are few and their protection is a step towards sustainable development according to the agenda 21.

Studies of heavy metals contamination to the environment is currently of importance because of their significant adverse health effects on human health. This study covers the relationship between the landuse and water quality. This will provide useful data for promoting river catchment protection and
Studies on the influence of land use on soil and water resources in Thika District, Kenya

landuse planning. Data collection was done from major land use zones in the Thika District. These were coffee, horticultural and semi urban zones. The heavy metals determined in and surrounding soils in different zones were chromium, lead, iron, copper, mercury and zinc. Statistical analysis revealed a correlation between land use and heavy metals in river water as well as from the soil. As the river flows through an area of intensive agricultural activities from Egaad Coffee Estate to Bluepost in Thika urban centre, the levels of heavy metals were noted to increase in both water and soil. However, levels of heavy metals in water were found to be low but could increase if river catchment region is not protected through afforestation and reduction of agricultural chemical input especially in the horticultural farms.

OBJECTIVES OF THE STUDY

- To determine the levels of chromium, lead, copper, zinc, iron and mercury in Chania River, a tributary of the Thika River as governed by different land use patterns.
- To investigate levels of chromium, lead, copper, zinc, iron and mercury in soils along Chania River as governed by different land use patterns.
- Assess the relationship between heavy metal levels in water and land use patterns.

METHODOLOGY

Sampling of water from Chania River was done once a month during the period September 1999 to June 2000. Water sampling points were identified in coffee zone and horticultural/semi urban centre. Three representative samples were collected at random at each location and pH was adjusted to 2 using nitric acid in samples for heavy metal analysis (APHA, 1989). Samples were stored in freezer pending analysis. Twenty-one samples were collected per site.

Top-soil (10 to 100cm) and sub soil (100 to 200cm) samples were collected from three distances (5m, 20m, 80m) from the river around each water sampling location. Three random samples were collected from each location and mixed to obtain 1 kg composite sample. Twelve representative samples were collected per site.

Water samples were preconcentrated chemically and filtered off on a 0.45μm pore size nucleopore membrane. Soil samples were air dried in the open and three pellets for each sample were prepared (Kinyua, 1982). X-ray fluorescence spectroscopy was used for heavy metal analysis and quantitative analysis using analysis of x-ray spectra by interactive least square fitting method (AXIL software). For validity of measurements certified reference soil was used from IAEA and values of elements were found to fall within required range. (IAEA, 1997; Mangala AXIL, 1999)

RESULTS

The results of the levels of heavy metals are as in Table 1 and 2 for both river water and soil samples respectively.

Heavy metal levels in water ranges were 0 to 40 ppb which was low while levels in soil was 0 to 215.6 μg/g (Table 1&2). Table 3 below reflects the drinking water regulations for heavy metal contaminants set by Kenya Bureau of Standards. These standards were based on WHO guidelines for Drinking Water Quality.

DISCUSSIONS

The levels of Iron were highest both in water and soil which may be attributed to the type of nitisols soil within this region containing high iron salts. Bluepost which is located in the semi urban region reflected higher amounts of heavy metals than Egaad coffee estate for both soil and water except Hg. For example, zinc in river water was 2.9 ppb and 11.6 ppb at Egaad and Blue Post respectively (Table 1).

Chania River receives agrochemical wastes from horticultural and coffee farms as it flows from Egaad coffee estate to Bluepost. Apart from the agrochemical wastes, high soil erosion is also a source of heavy metals in rivers through silt deposition. Majority of
Table 1. Levels of heavy metals for water samples from Chania River, Blue Posts (1C) before bridge and Egaad Estate, Chania river(2C).

<table>
<thead>
<tr>
<th>Location</th>
<th>Bluepost (1C)</th>
<th>Egaad Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone</td>
<td>Semi Urban</td>
<td>Coffee</td>
</tr>
<tr>
<td>Metal</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Cu ppb</td>
<td>2.3±0.18</td>
<td>0.575±0.18</td>
</tr>
<tr>
<td>Pb ppb</td>
<td>ND(1)</td>
<td>0.359±0.101</td>
</tr>
<tr>
<td>Zn ppb</td>
<td>11.6± 1.42</td>
<td>2.90± 1.42</td>
</tr>
<tr>
<td>Cr ppb</td>
<td>4.3±0. 125</td>
<td>1.09±0.125</td>
</tr>
<tr>
<td>Fe ppb(2)</td>
<td>37±0.96</td>
<td>9.49±0.96</td>
</tr>
<tr>
<td>Hg ppb</td>
<td>ND(1)</td>
<td>ND(1)</td>
</tr>
</tbody>
</table>

(1) ND- Not detected  
(2) Fe w%, iron data was presented on a weight basis because of the high content in soil.

Table 2. Levels of heavy metals in soil samples from Chania, Bluepost (1C) , Thika semi urban zone and Egaad Coffee Estate(2C).

<table>
<thead>
<tr>
<th>Location</th>
<th>Blue Post(1C)</th>
<th>Egaad Estate(2C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone</td>
<td>Thika Semi Urban.</td>
<td>Coffee</td>
</tr>
<tr>
<td>Metal</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Cu ug/g</td>
<td>45±14.76</td>
<td>34.6±3.5</td>
</tr>
<tr>
<td>Pb ug/g</td>
<td>ND(1)</td>
<td>ND(1)</td>
</tr>
<tr>
<td>Zn ug/g</td>
<td>205 ± 10.6</td>
<td>181.6±9.6</td>
</tr>
<tr>
<td>Cr ug/g</td>
<td>ND(1)</td>
<td>ND(1)</td>
</tr>
<tr>
<td>Fe w% (2)</td>
<td>11.7± 1.73</td>
<td>10.85±0.33</td>
</tr>
<tr>
<td>Hg ug/g</td>
<td>ND(1)</td>
<td>ND(1)</td>
</tr>
</tbody>
</table>

small scale farmers had cleared most of the trees within their farms as compared to the large scale farmers hence aggravating soil erosion. Other sources of pollutants into rivers are the many stone mining sites along Chania Rivers which are normally left exposed after mining is completed.

Chromium and mercury in soil were not detected at both the locations maybe because the locations are far from the industrial area. Therefore, the soil probably does not receive much atmospheric particulate deposition from polluted industrial areas. Analysis revealed high variations in mean concentrations of the heavy metals in the soil within the two locations (Table 2). Mean copper levels range was 34.6 ug/g to 45 ug/g which may result from the pesticide application in adjacent farms. Zinc levels were significantly higher than other metals with a mean of 205ug/g.

High levels of Zinc in the soil at Blue Post maybe attributed to both agrochemical sources, sedimentation and waste discharges from residential estates within this area. However, more investigation is required to identify the sources. Chromium, mercury and lead were observed to be low in soils as well as water.
Data collected for both water and soil in this study reveal a correlation between the landuse and levels of heavy metals in river water and soils. Xinzhao et al., (1997), reported that high density of point pollution sources in urban areas affect water quality. In developing countries most planning agencies do not have resources to extensively collect landuse and water quality data for developing plans, hence water quality data may often be missing in a land use plan. A challenge is how to plan landuse while promoting sustainable use of water.

**CONCLUSIONS**

From the study, a few conclusions can be made:

Levels of heavy metals in Chania River are influenced by landuse activities, as the amounts were higher down stream in Thika urban zone at BluePost than in the upstream Egaad coffee estate. As the Chania River flows through agricultural land from Egaad coffee estate to Thika urban zone it receives more agrochemical waste from horticultural farms hence the resulting increase downstream. However, the level of heavy metals in water was found to be lower than limits in drinking water. Heavy metals are a good water quality indicator that is related to land use.

The heavy metal levels in soils were higher in the Thika urban centre than in the Egaad coffee estate. The trend of heavy metals concentration was the same in soil and water. For example Zinc and Iron were found to be high in both water and soil. Iron and zinc were found to the higher in comparison to other metals in both water and soil. Lead and mercury were found to be below detection limit in both soil and water.

Although heavy metals were relatively low in the water there was clear indication that it may increase in future. Therefore landuse planning incorporating water quality data needs to be emphasized to improve water protection for our future generation.

**RECOMMENDATIONS**

To prevent increase of heavy metals in soil and water there is need for proper landuse planning such as reduction of agrochemical inputs especially from the horticultural farms.

Incorporating integrated pesticide control, enhance agricultural extension to farmers, organic farming or enhancing soil conservation methods such as afforestation or agroforestry would further reduce heavy metal pollution.

Controlling tree felling especially in the Aberdare region which is the part of catchment region for River Chania. Large sections in the middle of the forest were found to have been cleared for shifting cultivation therefore increasing soil erosion as well as
adversely affecting the water catchment region.

Control of the stone mining areas and covering excavated areas to prevent soil erosion and excessive sedimentation in rivers.

More studies need to be done on methods to reduce agrochemical inputs into large scale horticultural farms.

REFERENCES


