

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background of the research

Pollution has been defined as changes in the physical, chemical or biological quality of the resources (air, land and or water) that is injurious to the existing, intended or potential uses of the resource (Novotny and Chesters, 1981). The sources or causes of pollution can be classified as either point sources (PS) or non-point sources (NPS) of pollution. Point sources of pollution are defined as pollutants that enter the transport routes at discrete, identifiable locations and that can usually be measured. Non point sources are defined as diffuse, water flows on the surface dissolving and washing away pollutants and soil sediments along its path and finally discharging into receiving waters (Stevenson and Wyman, 1991; Taebi and Droste, 2004). There are several general characteristics that describe non point source pollution;

- i) NPS discharges enter surface waters in a diffuse manner and at intermittent intervals that are related mostly to that occurrence of meteorological events
- ii) Pollution arises over an extensive area of land and is in transit overland before it reaches surface waters
- iii) Generally, NPS cannot be monitored at their point of origin and their exact source is difficult to trace
- iv) Elimination or control of pollutants must be directed at specific sites

- v) NPS pollutants cannot be measured in terms of effluent limitations

Several major factors have severely disrupted the environmental (ecological) balance, resulting in accelerated increases of nonpoint sources pollution (Novotny and Olem, 1994). They are

- population increase (sometimes termed explosion) especially in developing countries
- land-use transformation and conversion of land to intensive agriculture and increased use of chemicals to sustain high agricultural yield
- urbanization and industrialization
- increased living standard, resulting in an increased per capita use of natural resources and increasing waste generation

There are various types of diffuse sources of pollution, but the ones that are most common and regarded as having the most significant impact are agriculture (mainly nutrients and pesticides), transport (road, air, shipping), atmospheric deposition (especially on lakes and the sea), leaching and corrosion of building materials and consumer products, urban and industrial site run-off, storm water and forestry activities (Moxon, 1998). Also, some non-agricultural land use (e.g. golf courses) can be a significant contribution for nonpoint pollution source (Evans and Nizeyimana, 1998). Due to complex modes of transport and site-specific characteristics, NPS pollutants are generally more difficult to control compared to point sources. Because of the difficulty to quantify and understand the processes that contribute to pollutant generation, transport and deposition, the effective management of non-point source control is complex and always involved non-standard local boundaries. In addition the cost involved is high whereas the benefits are often not obvious.

Among non point sources, urban stormwater runoff was reported as a major contributor to the pollution of many receiving waters (Saget *et al.*, 1996; Appel and Hudak, 2001; Brezonik and Stadelmann, 2002; Buffleben *et al.*, 2002; Lee *et al.*, 2004). The quantity and quality of stormwater runoff from urban areas are influenced by many factors including human activities, meteorological variables and catchment

characteristics. The meteorological variables include rainfall, temperature, wind and inter event periods, whereas the catchment characteristic include catchment area, topography, landuse, soil types and conditions, population density, drainage systems and waste disposal practices (Driver and Tasker, 1990).

## **1.2 Statement of the problem**

Typically, there are two main impacts of urbanization. First the hydrology is modified causing more rapid flow path and the second, increase of human activities that adds pollutants. Construction of roads and buildings reduce the vegetated area and increase the catchment's imperviousness, while the groundwater recharge is reduced (Whipple, 1983; Lazaro, 1990). These often lead to enhancement of overland flow, greater peakflow with a shorter time to peak and decrease base flow. In addition, rapid population growth and land disturbance generate significant sources of contaminants especially from residential and industrial areas. Ineffective handling of urban wastewater is quite common and results in adverse environmental problems (Bedient *et al.*, 1978; Lee *et al.*, 1996).

The more rapid hydrological pathway and readily available sources of pollutants are responsible for the quality degradation of many receiving water systems (Petry *et al.*, 2002; Pieterse *et al.*, 2003; Taebi and Droste, 2004). Numerous studies on urban runoff quality conducted in different parts of the world over recent decades have shown that runoff can carry relatively high concentrations of a variety of pollutants. In the early stages of runoff, the land surfaces, especially the impervious surfaces like streets and parking areas, as well as solids accumulated in the collection system during the antecedent dry weather period, are flushed by stormwater. Normally, the velocity of the flow is high in urban drainage systems so that the runoff is able to transport higher volume of sediments. In small catchments, this can transport large loading of pollutants in the form of a first flush.

The loadings and concentrations of suspended solids, nutrients and other contaminants are much higher in urban stormwater runoff than in runoff from unimpaired and rural areas (Sartor and Boyd, 1972; Vaze, 2002). These pollutants are transported into water bodies, such as lakes and rivers, especially during rainy season and may lead to eutrophication. Nitrogen in the form of ammoniacal-N and nitrate, and phosphorus as orthophosphates are readily available for plant growth. This could lead to algal blooms and excessive macrophytic growth and causing depletion of dissolved oxygen upon death and decay. The long term effects would include eutrophication, sedimentation of lakes and rivers, threatening habitats, losses of biodiversity, channel constriction and more frequent flooding.

The existence of the first flush of pollutants provides an opportunity for stormwater managers and engineers to control water pollution in an economic and efficient way. If most of the urban-surface pollutant load were transported during the initial phase of a storm, then a rather small volume of runoff storage would be needed to treat and remove the bulk of urban-surface pollutants. As a result, controlling the first flush has become the most practiced criterion for the design of stormwater treatment facilities; and first flush collection systems are employed to capture and isolate this most polluted runoff, with subsequent runoff being diverted directly to the stormwater system and finally into the receiving environment (Deng, 2005).

Concern over continuous degradation of urban runoff quality, emerged only recently as opposed to quantity aspects of flood mitigation. Unlike in the developed countries especially the US, Japan and the EC where funding are more readily available, monitoring of urban runoff in the developing countries generally receive less priority. This despite the fact that the latter are experiencing much more severe water quality problems. A comprehensive understanding on the processes of contaminants transport and loadings are crucial for formulating effective urban water and waste-water management strategies (Brezonik and Stadelmann, 2002). To date coordinated and comprehensive study on these aspects, particularly in tropical region, is still scarce.

Systematic evaluation of non point source impacts often requires water quality models. Models provide a predictive ability, which enables potentially expensive water quality management options to be evaluated and tested prior to their implementation. This is far more cost-effective by considerably reduce financial resources required for data collection and provides a systematic and rigorous framework for examining water quality impacts. In this study the Storm Water Management Model (SWMM) has been selected. This model performs both continuous and single event simulation. The model can also simulate backwater, surcharging, pressure flow, looped connections and has a variety of options for quality simulations, including traditional buildup and wash off formulations (Novotny and Olem, 1994).

A major advantage of using simulations model is the insight gained by gathering and organizing data required as inputs to the mathematical algorithms that made up the overall model system. Besides, many alternative schemes for development and flood control can be quickly tested and compared with simulation models (Huber and Bedient, 1992).

### **1.3 Objectives**

The overall aim of this study is to gain a better understanding on the extent of non-point source pollution in developed urban catchments. Specifically the study will:-

- i) Quantify loadings of major pollution from selected urban catchments
- ii) Investigate the influence of hydrological regime (rainfall and runoff) on the pattern of pollutant loading
- iii) Simulate the NPS pollution loadings using Storm Water Management Model (SWMM)

## 1.4 Scope of work

In order to archive the above objectives the following tasks were carried out:-

- 1) Selecting two small catchments representing residential and commercial catchment;
- 2) Measuring discharge and water level during low flow and storm flow;
- 3) Baseflow and stormflow sampling of water;
- 4) Labarotary analysis of Biochemical Oxygen Demand (BOD<sub>5</sub>), Chemical Oxygen Demand (COD), Suspended Solids (SS), Nutrients (NO<sub>3</sub>-N, NO<sub>2</sub>-N, NH<sub>3</sub>-N and P) and heavy metal (Pb);
- 5) Data analysis including Event Mean Concentration (EMC), pollutant loading, statistical analysis, box plot analysis, hysteresis loops and first flush analysis;
- 6) Simulation of NPS using XP-SWMM model in terms of water quantity and quality