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# Effects of Infiltration Trenches and Bio-Retention Ponds on Stormwater Runoff in Eldoret Town

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***Abstract*— The overall objective of the research was to evaluate the influence of low impact developments (LIDs) on the generated runoff in Eldoret town, Kenya. The specific LIDs investigated were the infiltration trenches and bio-retention ponds. On methodology, rainfall was measured using rain gauge while discharge was measured using the current meter. Simulation was done using Storm Water Management Model (SWMM) version 5. The results indicated a reduction of average runoff flow by 25% when infiltration trenches were used to an extent of 100% treatment of impervious area and a reduction in total runoff volume by 19.6%. In addition, bio-retention ponds reduced average runoff flow and volume by 1.6% and 4.4%, respectively. Therefore it was concluded that bio-retention cells and infiltration trenches have an effect of reducing flow and total volume in the study area and can be used to control flooding. Further study is recommended on effect of permeable pavements.**

***Keywords: Bio-retention pond; infiltration trenches; low impact developments; swmm***

## I. INTRODUCTION

Floods are dangerous, but when studied and controlled, they can be controlled and managed. Therefore, there was a need to determine how LIDs can reduce flood effects in Eldoret town in Kenya which has been experiencing flooding. The study was limited to the investigation of the rainfall-runoff relationship and runoff control in the study area using the SWMM model version 5.

Owing to accelerated rate of build up area coupled with climate change, calls for another way of controlling floods other than quickly discharging flood whenever it rains [1]. In towns and cities use of low impact development (LID) is gaining momentum [2]. LID technique can be used for planning as well as in design to control environmental impacts of floods in any given area [3]. The aim of LIDs is to decrease amount of flood within a sub-catchment consequently leading to more infiltration and reduced runoff [4].

LID techniques include: rain barrels, rain gardens, detention ponds, green roofs and porous pavement [5]. LID devices include structural measures such as wetlands, ponds, swales, rainwater tanks, bio-retention devices, vegetated filter strips, and filter strips and can also include non-structural measures such as alternative layouts of roads and buildings to minimize imperviousness and to maximize the use of pervious soils and vegetation, contaminant source reduction, and programs of education to modify activities [6]. The LID approach ensures that rainwater is contained and managed at the source instead of being allowed to drain into existing open channels [7].

SWMM Model version 5 can model LIDs and gives eight options for the techniques; bio-retention ponds, green roofs, rain barrels, permeable pavements, vegetative swales, infiltration trenches, rain gardens and rooftops [8]. In this study we used bio-retention ponds and infiltration trenches. Bio-retention ponds are depression areas built to collect and treat stormwater runoff. Water held in depression areas can infiltrate into the soil and recharge groundwater while evapotranspiration can decrease the amount of water entering the stormwater system [9]. Infiltration trenches are narrow ditches filled with gravel that intercept runoff from upslope impervious areas [10], that provide storage volume and additional time for captured runoff to infiltrate into the native soil below. Infiltration trenches are also known as soak-aways [11]. A general design of an infiltration trench constitutes of a linear excavation filled with a coarse stone aggregate, such as single or macadam [12].

Storm Water Management Model (SWMM) version 5 was selected for this research due to its ability to model and simulate urban rainfall-runoff. This latest version is also able to model and simulate the effect of low impact developments (LIDs) on runoff [13] an attribute that other hydrology models lack.

Gaborit [14] applied SWMM version 5 in a study of improving the performance of stormwater detention basins by real-time control using rainfall forecasts. Many other studies involving the SWMM5 model have been done in different parts of the world [15] and [16].

## II. METHODOLOGY

This study was conducted on a sub catchment in Eldoret town which lies within latitude 0.26º3’ N - 0.35º34’ N and longitude 35.12º21’ E - 35.20º31’ E. Simulation was done using SWMM version 5 which had been calibrated and validated for the study area. Two low impact developments (infiltration trench and bio-retention ponds) were considered for simulation in this study to determine their influence on runoff generation. Three scenarios were formulated; application of infiltration trenches to treat 100% of the impervious area, application of bio retention ponds to treat 100% of the impervious area, and a combination of both treatments each treating 50% of the impervious area. Simulations were run and compared with no low impact development scenario as shown in Table I. Maximum recorded daily rainfall observed between 2009 and 2019 was applied to perform this evaluation. The rainfall amount was 72.78 mm.

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TABLE I. SCENARIOS OF LID TREATMENTS

| Scenario | *Description* |
|---|---|
| Control | Simulation run without LID treatment |
| Scenario 1 | Infiltration trenches (IT) used to an extent of 100% of impervious area |
| Scenario 2 | Bio-retention cells (BRC) used to an extent of 100% of impervious area |
| Scenario 3 | A mixture of infiltration trenches and bio-retention cells, each used to an extent of 50% of the impervious area. |

## III. RESULTS AND DISCUSSION

The results indicated a reduction of average runoff flow by 25% when infiltration trenches were used to an extent of 100% treatment of impervious area and a reduction in total runoff volume by 19.6%. Bio retention cells used to an extent of 100% treatment of impervious area resulted in a slight reduction of average flow by 1.6% while total runoff volume was reduced by 4.4%. The combination treatment reduced total runoff volume and average flow by 10.7% and 5.9% respectively. The results are presented in Table II.

TABLE II. AVERAGE FLOW AND TOTAL RUNOFF FOR THE THREE SCENARIOS OF LIDS TREATMENT

| **Parameter** | ***Without LIDS*** | ***100% BRC*** | ***Combination of 50% IT and 50% BR*** | ***100% IT*** |
|---|---|---|---|---|
| Average Flow ($m^3/s$) | 0.256 | 0.252 | 0.241 | 0.192 |
| Total volume ($m^3/s$) | 93,711 | 89,579 | 83,640 | 75,435 |

In a related study done in Rwanda by [5], the effect of bio-retention ponds on mitigating floods in Nyabugogo catchment was assessed by simulating scenarios and the results showed good performance on reducing water depth; 9.5 % less compared to no application of LID.

It can be deduced from this study that low impacts developments, in this case, infiltration trenches and bio-retention ponds have an effect of reducing flow and total volume in the study area. The two low impact developments can therefore be used for flood control in the study area. It can further be noted that infiltration trenches are superior to the bio retention ponds in reducing flow and runoff in the study area.

## IV. CONCLUSION AND RECOMMENDATION

Infiltration trenches are the most effective low impact developments in reducing flooding in the study area. The infiltration trenches reduced runoff flow by 25% and total volume by 19.6% as compared to bio-retention ponds which reduced runoff flow and volume by 1.6% and 4.4%, respectively. Infiltration trenches installation is recommended to reduce and control flooding in the study area and further research is required on permeable pavements in the study area like the ones made of paving blocks and quarry dust.

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