ISSN Application No. 21799

Journal of Water Resources and Civil Engineering Technology

Volume No. 7

Issue No. 2

May - August 2023

ENRICHED PUBLICATIONS

ENRICHED PUBLICATIONS PVT. LTD

S-9, IInd FLOOR, MLU POCKET,
MANISH ABHINAV PLAZA-II, ABOVE FEDERAL BANK,
PLOT NO-5, SECTOR-5, DWARKA, NEW DELHI, INDIA-110075,
PHONE: - + (91)-(11)-47026006

Journal of Water Resources and Civil Engineering Technology

Aims and Scope

Journal of Water Resources and Civil Engineering Technology is peer reviewed journal for the presentation of original contributions and the exchange of knowledge and experience on the management of water resources. In particular, the journal publishes contributions on: Water resources assessment, development, conservation, planning and design of water resource systems; and operation, maintenance and administration of water resource systems etc.

The topics covered in this journal are:-

1. Water demand and consumption;
2. Applied surface and groundwater hydrology;
3. Water management techniques;
4. Simulation and modeling of water resource systems;
5. Forecasting and control of quantity and quality of water;
6. Economic and social aspects of water use;
7. Legislation and water resources protection

Journal of Water Resources and Civil Engineering Technology

Journal of Water Resources and Civil Engineering Technology

(Volume No. 7, Issue No. 2, May - August 2023)

Contents

Sr. No.	Articles/ Authors Name	Pg. No.
1	Estimation of Organic Matter Content in Drinking Water Sources; Assuming Humic Acid as the Predominant Species of Organic Matter in Water *– D. Ilangangedara, A.n. Navarathna*	51 - 56
2	Physico- Chemical Quality of Waste Water and the Risk of Pollution of Bechar River South West of Algeria *– Kendouci Mohammed Amin, Mebarki Saliha, Bendida Ali, Kharroubi Benali*	57 - 62
3	Impact of Urbanization on Hydrological Responses and the Efficiency of Low Impact Development (LID) Implementation in Amman, Jordan *– H. F. Gammoh, A. Y. Shamseldin*	63 - 74
4	Acoustic Noise Loggers' Financial Analysis for Expanding their Coverage Over Montreal's Water Network *– Soliman Abu- Samra, Ahmed Abdalmoujoud, Tarek Zayed*	75 - 82
5	Evaluation of Response Reduction Factor of Elevated Storage Water Tank under the Hydrostatic Pressure *- Apurva V., Simon J.*	83 - 88

Estimation of Organic Matter Content in Drinking Water Sources; Assuming Humic Acid as the Predominant Species of Organic Matter in Water

[1] D. Ilangangedara, [2]A. N. Navarathna

[1]National Water Supply & Drainage Board , Sri Lanka

[2]Department of Chemistry, University of Peradeniya, , Sri Lanka

E-mail: [1]dilangangedara@yahoo.com, [2]ayanthi.pdn@gmail.com

ABSTRACT

Natural Organic matter (NOM) is a complex matrix of organic compounds present in natural surface water sources (Mahvi et al., 2009). Humic substances (HS) are the predominant type of natural organic matter (Richard et. al., 2009). Not only HS affect the odour, colour and taste of water but also affects several processes in drinking water treatment as such as biofouling, increasing chlorine demand etc. (Aoustin et al., 2001). Halogenated HS during water treatment are collectively referred to as disinfection by products (Kurt et al, 2013). HS cause formation of disinfection by products (DBPs) such as chloroform, bromo-dichloromethane, etc., which are suspected carcinogenic compounds (Yildiz, et al., 2008). For this reason, the USEPA currently regulates two classes of DBPs commonly found on drinking water – trihalomethanes (THMs) and halo acetic acids (USEPA, 2009). As the HS predominates in NOM, HS can be used to determine the concentrations of NOM. Still, National Water Supply and Drainage Board does not have a reliable method to measure the concentrations of NOM in water, in its regional laboratories. Therefore, the amount of organic matter entering the drinking water treatment plant is unrevealed. The objective of this study is to quantify the NOM in natural drinking water sources, using available laboratory facilities. Standard solutions of HS were prepared using the commercially available Humic acid powder (Sigma Aldridge brand). A graph was obtained by scanning the samples, against series of wave lengths from 990 to 1100 nm, Using the DR 5000 spectrophotometer. Then the wave length range was filtered to 230 nm to 630 nm, as the absorbance at the other wave lengths were not given considerable variations. The results obtained were used to construct a graph of Absorbance Vs Wave length and it was used to estimate the concentrations of HS in unknown samples.

The highest concentration of HS sample has widest absorbance range, while the least concentration has the narrowest curve. Using the results obtained from graph of absorbance Vs Wave length the concentration of HS in the Doluwa water could be estimated. The graph of absorbance Vs Wave length can be used as a reliable method to estimate the Organic matter content in water samples. All the raw water samples measured during the three months period of time (from August to October – 2018), collected from 13 locations of Kandy South region (39 samples), contained organic matter content of less than 0.1 mg/L, which means water sources are less contaminated and still far away from the danger of DBPs.

Keywords - Natural Organic matter, Humic acid, Disinfection by products

I. BACKGROUND/ OBJECTIVES AND GOALS

Background

Natural Organic matter (NOM) is a complex matrix of organic compounds present in natural surface water sources (Mahvi et al., 2009). Not only it does affect the odour, colour and taste of water but it also affects several processes in drinking water treatment (Aoustin et al., 2001). The presence of natural organic matter in water has been identified as one of the main contributors to the problems associated with the supply of potable drinking water (Parkinson et al., 2001).

Humic substances (HS) are the predominant type of natural organic matter present in ground and surface waters (Richard et. al., 2009). On the basis of their solubility in water and as a function of pH, humic substances are generally classified into humic acids (HA), fulvic acids (FA) and humin (Uyguner and Bekbolet, 2005).

Humic substances cause formation of disinfection by products (DBPs) such as chloroform, bromo-dichloromethane, etc., which are suspected carcinogenic compounds (Yildiz, et al., 2008).

Chlorine as a disinfectant, although essential for pathogen control, leads to the halogenation of organic matter present in source water (Croue' et al 1999). Halogenated (Chlorine and Bromine) containing compounds form from dissolved and particulate organic carbon during water treatment and are collectively referred to as disinfection by products (Kurt et al, 2013). Although only a small fraction of the organic carbon present in source water reacts to form Disinfection by products (DBPs) several DBPs have been identified as mutagenic and carcinogenic (Krasner et al, 2006). For this reason, the USEPA currently regulates two classes of DBPs commonly found on drinking water – trihalomethanes (THMs) and halo acetic acids (USEPA, 2009). In addition to being a source of DBPs, organic carbon contributes to biofouling, increases chlorine demand, and can affect aesthetic qualities of water such as taste, odour, and colour (Cooke and Kennedy, 2001).

The humic substances are also responsible of the formation of water-soluble complexes of humic substances with metal ions is of particular interest, because complexing can increase concentrations of these ions in natural waters far above the concentrations that could be expected based on the solubilities of inorganic species (Boggs et. al., 1985). The measurement of ultraviolet absorbance at 254 nm (UVA254) has been used by the drinking water industry as a proxy for DOC concentration for several decades (Edzwald et al., 1985). Dissolved Organic carbon or DOC is a measurement of the amount of organic matter in water that can be passed through a filter, commonly 0.45 µm. In addition to providing information about DOC concentration, absorbance data can provide insight into the chemical makeup of the DOM pool (Rathban, 1996).

Research Goals

NOM can be defined as a mixture of complex organic compounds that universally present in natural waters. High NOM content in water strongly impact the water quality and treatment in several ways. Besides that, NOM also acts as the main precursor to disinfectant by products produce from the reaction of NOM and disinfectant during water treatment. DBPs are known to be carcinogenic to human and animals. In addition, NOM are capable of complexing with metal ions and bringing them to the water sources.

As the HS predominates in NOM, HS can be used to determine the concentrations of NOM. Because when the NOM concentration is higher, the defective outcomes will be higher due to them. Still, National Water Supply and Drainage Board does not have a reliable method to measure the concentrations of NOM in water, in its regional laboratories. Therefore, the amount of organic matter entering the drinking water treatment plant is unrevealed.With the available laboratory facilities in regional levels, National Water Supply and Drainage Board of Sri Lanka has to find a method to estimate the amount of organic matter content in water that is entering the treatment plant.

Objectives

The objective of this study is to realize a reliable method using available laboratory facilities, to quantify the NOM in natural water sources, which are used by the National Water Supply and Drainage Board as drinking water origin.

II.METHODS

Standard solutions of HS were prepared using the commercially available Humic acid powder (Sigma Aldridge brand). A graph was obtained by scanning the different standard samples, against series of wave lengths from 990 to 1100 nm, Using the DR 5000 spectrophotometer. Then the wave length range was filtered to 230 nm to 630 nm, as the absorbance at the other wave lengths were not given considerable variations. Then the results obtained from the standard graph was compared with the unknown samples, the concentration of the organic matter in the sample can be estimated.

III. RESULTS

Figure 1 shows the absorbance patterns of different concentrations of organic matter samples. The highest concentration of organic matter sample has wider absorbance range, while the least concentration has the narrow absorbance range.

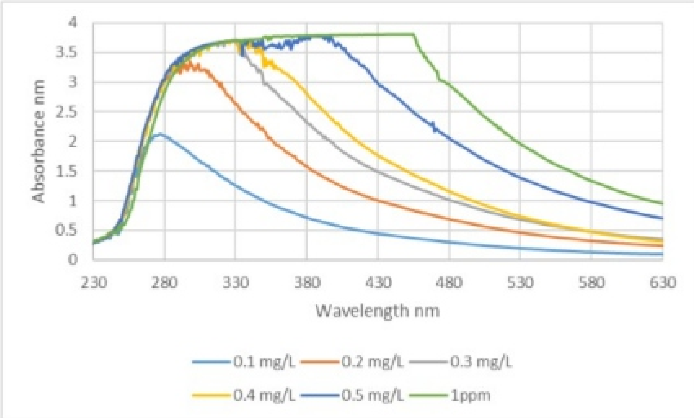


Figure 1: absorbance patterns of different concentrations of organic matter

The results stipulated in Figure 1 were used to estimate the concentrations of organic matter content in naturally occurring water samples collected from various locations.

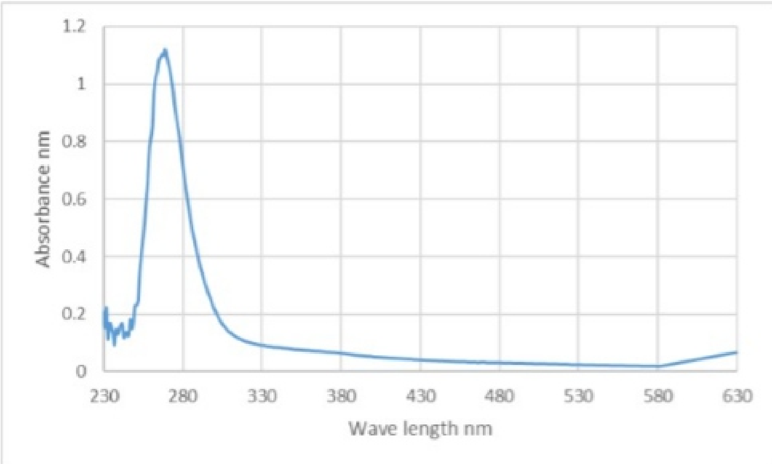


Figure 2: Graph of Absorbance Vs Wave length for Doluwa WSS

When the results obtained from the Figure 1 graph is used, the concentration of organic matter content in the water sample collected from Doluwa can be estimated.

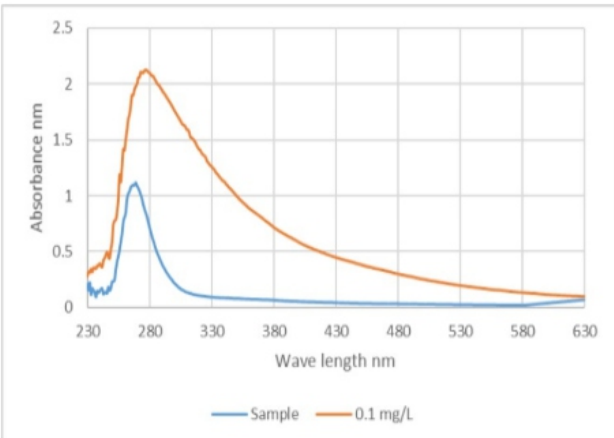


Figure 3: Comparison of absorbance of the Doluwa sample and 0.1 mg/L HS standard sample

According to the Figure 3, sample contains organic matter content of less than 0.1 mg/L.

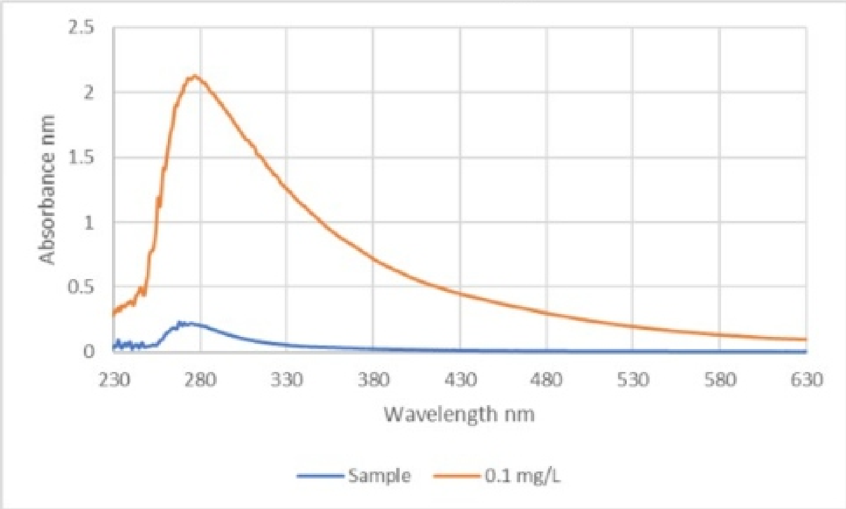


Figure 4. Comparison of absorbance of the Nawalapitoya sample and 0.1 mg/L HS standard sample

IV. CONCLUSION

The graph shown in the figure 1 can be used as a reliable method to estimate the Organic matter content in water samples. All the raw water samples measured during the three months period of time (from August to October – 2018), collected from 13 locations of Kandy South region (39 samples), contained organic matter content of less than 0.1 mg/L, which means water sources are less contaminated and still far away from the danger of DBPs.

REFERENCE

[1] Croue', J.P., DeBroux , J.F., Amy, G.L., Aiken, G.R., Leenheer, J.A. (1999). Natural Organic matter – Structural characteristics and reactive properties. Formation and control of disinfection by products in drinking water. American Water Works Association.

[2] Kurt, D.C., Tamara, E.C.K., Jami, H.G., John, F.S., Bryan D.D., Brian A.B. (2013). Sources and characteristics of Organic matter in the clackmas River, Oregon, Related to the formation of disinfection by products in treated drinking water. Scientific investigations rofeport. U.S. Department of the interior survey. U.S. Geological Survey.

[3] Krasner, S.W., Weinberg, H.S., Richardson, S.D., Pastor S.J., Chinn, R., Sclimenti, M.J., Onstad, G.D., Thurston, A.D. (2006). Occurrence of a new generation of disinfection byproducts: Environmental Science and technology. Vol. 40, N0. 23. Pp 7175-7185

[4] United States Environmental Protection Agency (USEPA). 2009. National primary drinking water regulations – Minor correction to stage 2 disinfectants and disinfection byproducts rule and changes in reference to analytical methods : Federal Register, June 29, 2009. Vol 74, No. 123.

[5] Cooke, G.D., Kennedy, R.H. (2001). Managing Drinking water supplies. Journal of Lake and Reservoir management. Vol. 17. No. 3.

[6] Edzwald, J.K., Becker, W.C., Wattier, K.L. (1985). Surrogate parameters for monitoring organic matter and THM precursors: Journal of American Water Works Association. Vol. 77. No. 4.

[7] Rathban, R.E. (1996). Trihalomethane and non-purgeable total organic halide formation potentials of the Missisipi River: Archives of Environmental contamination and Toxicology. Vol. 30. No.2.

[8] Weishaar, J.L., Aiken, G.R., Bergamaschi, B.A., Fram, M.S., Fujii, Roger, Mopper, Kenneth. (2003). Evaluation of specific ultraviolet absorbance as an indicator of the chemical composition and reactivity of dissolved organic carbon. Environmental science and Technology. Vol. 37. No.20.

[9] Helms, J.R., Stubbins, Aron, Ritchie, J.D., Minor, E.C., Kieber, D.J., Mopper, Kenneth. (2008). Absorption spectral. Slopes and slope ratios as indicators of molecular weight, source, and photobleaching of chromophoric dissolved organic matter. Limnology and Oceanography, Vol. 53. No. 3.

[10] Spencer, R.G.M., Stubbins, Aron, Hernrs, P.J., Baker, Andy, Mopper, Kenneth, Aufdenkampe, A.K., Dyda, R.Y., Mwamba, V.L., Mangangu, A.M., Wabakanghazi, J.N., Six, Johan. (2009). Photochemical degradation of dissolved organic matter and dissolved lignin phenols from the Congo River. Journal of Geographical Research – Biogeosciences. Vol. 114.

[11] Mahvi, A.H., Maleki, A., Rezaee, R., Safari, M. (2009). Reduction of Humic substances in water by application of ultrasound waves and ultraviolet irradiation. Iran Joural of Environmental Health Science Engineering. Vol.6. No. 4.

[12] Aoustin, E., Schafer, A.I., Fane, A.G., Waite, T.D. (2001). Ultrafiltration of natural organic matter. Sep. Purification Technology.

[13] Parkinson, A., Barry, M.J., Roddick, F.A., Hobday, M.D. (2001). Preliminary toxicity assessment of water after treatment with UV-IR radiation and UVc/H2O2. Water research. Vol. 35

[14] Richard, T.L., Karen, H.T. (2009). Critical comparison of Humic acids test methods. Communications in soil science and plant analysis. ISSN 0010-3624

[15] Uyguner, C.S., Bekbolet, M. (2005). A comparative study on the photocatalytic degradation of humic substances of various origins. Desalination. Vol. 176.

[16] Boggs, S., Livemore, D., Seltz, M.G. (1985). Humic Substances in natural waters and their complexation with trace metals and radionuclides : A review. Argonne National Laboratory, 9700 South Case Avenue, Argonne, Illinois, 60439.

Physico- Chemical Quality of Waste Water and the Risk of Pollution of Bechar River South West of Algeria

[1]Kendouci Mohammed Amin, [2]Mebarki Saliha, [3]Bendida Ali, [4]Kharroubi Benali

[1,2,3]Department of Civil Engineering and Hydraulic, university of Bechar, Algeria.

[2,3,4]Department of Hydraulic. University of Science and Technology Oran –Mohamed Boudiaf B.P.1505 El-M'Naouer 31000 Oran, Algeria.

E-mail: [1]aminekendouci@gmail.com

ABSTRACT

In urban environment, the increase in population generates considerable quantities of waste water which is treated in the purification plants to specialize or reject directly without control in the courts of water case of Bechar River. Because of their various origins (domestic rejections), this water is generally charged in organic, mineral elements and in micro-organisms of which some could be harmful with health and strongly takes part in the degradation of the tablecloths which could be irreversible.

The town of Bechar (Southern Algerian West) which is in an arid Saharan area knows like all the Algerian cities of the problems of surface and underground pollution the waters, whose main causes are: the discharge of waste water in nature without purification and the absence of the systems of purification and depolution of waste water. The present study is undertaken on the course of Bechar River, carried out in April 2017 revealing a polluting load: (Nitrate 7.94 mg/l, Nitrite 0.6 mg/l, Ammonium 26.60 mg/l, NTK 62.18 mg/l).

In April 2014, of samplings of waste water noted Wi were realized according to the recommendations of WHO. The choice of the sites was fixed according to the direction of flow. The results obtained according to the study analyzes physic- chemical samples of the rejections testify in their majority that a contamination of subterranean water of the tablecloths by waste water of the river according to a process of infiltration which depends on several environmental and climatic factors is extremely probable and which an urban treatment of the rejections is paramount to protect the tablecloth and the ecosystem.

Keywords - Algeria, Bechar River, Environment, Urban Rejection, Contamination, Parameters Physico-Chemical

I. INTRODUCTION

The city produces an impact on ecological resources, global systems and modifies the environment in all its components, physical and human. Today, the preservation of our environment and our water resources depends on our ability to clean wastewater at low prices before they return to nature.

The issue of sewage disposal has become increasingly important in the early seventies. Given the general concern expressed worldwide face the problem of growing pollution of the human environment as their name suggests. Wastewater is water that after domestic or industrial use, convey waste treatment is a necessity to preserve the environment and direct human preserve the rivers and especially groundwater.

The city of Bechar found in arid Saharan region, the total contribution of precipitation average is 72 mm, the volume of wastewater discharged through the sewerage system of the city is estimated to 25000m^3 /day (KENDOUCI 2012). It knows as all Algerian cities problems of pollution of surface water and groundwater, whose main causes are:

-The discharge of wastewater in nature without treatment;

-Absence of sewage systems and wastewater treatment;

-Presence of solid waste dumps near the river;

-Irrigation of agricultural land by the polluted wastewater.

The water supply of the city is provided by surface water and groundwater from aquifers and other groundwater unrecognized in the vicinity of the river source water discharges (risk of infiltration). (KENDOUCI 2012).

II.MATERIALS AND METHODS

In April 2014, samples of wastewater noted Wi were performed according to the WHO recommendations. The choice of sites was determined according to the direction of flow.

W1

W2

W3

W4

Fig.1. wastewater into the river of Bechar

Samples of wastewater are collected in polyethylene bottles of 1.5 liters volume for the physicochemical analysis, in the laboratory it was the mixture of samples Wi to give a single sample called "wastewater ".

The measured physical parameters are: pH, salinity, conductivity and TDS. Chemical parameters determined are: chloride, nitrate, nitrite and phosphate according to standard analysis techniques. The assay methods used are as follows:

- pH, salinity, TDS and conductivity, potentiometric method (861 Consort)
- Nitrate is determined by the potentiometric method (HI 121) using a specific electrode;
- Ammonium AFNOR T90-015 on a filtered sample, blue methods indophenols;
- Nitrites, AFNOR, 1986; Phosphates, AFNOR NF T90-023 on a filtered sample by colorimetric method.
- Sodium and potassium: flame spectrophotometer JENWA clinco LPFP7.
- COD : Eco thermo reactor VELP scientific. (RODIER J. 2005; DEGREMONT 1978; FRANCK. R. 2002)

III. RESULTS AND DISCUSSION

The results of this study are explained in discussing the measured parameters, including measurements made in the laboratory

Conductivity, salinity and pH

Wastewater shown in Figure 1, show a significant electrical conductivity equal to 4.05mS/cm salinity of 2.02 g / l, which proves that wastewater is loaded.

Wastewater from the river is characterized by a pH equal to 8.32.

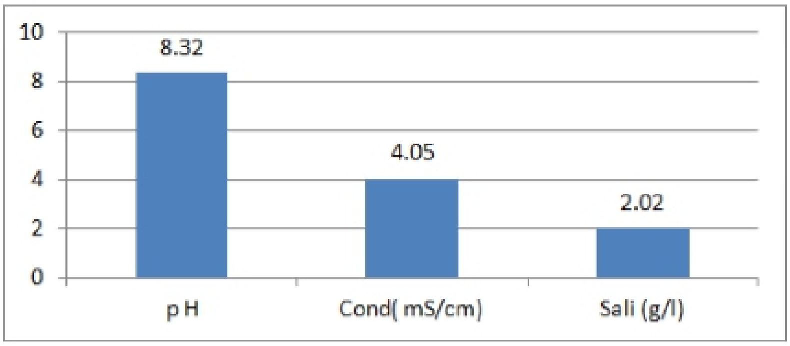


Figure 2. Values of Conductivity, Salinity and pH.

COD, BOD and suspended solids

The biochemical oxygen demand (BOD) of wastewater is 168 mg/l, by convention, the BOD necessary conditions for the test was determined after incubation for 5 days at 20 ° C in the dark, the chemical oxygen demand oxygen demand (COD) is 220mg/l. The determination of the content of suspended solids in the wastewater is filtered and gives a level of 180 mg/l. (KENDOUCI 2012)

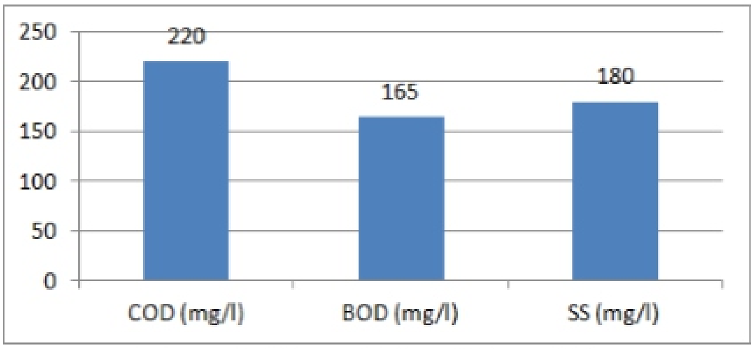


Figure 3. Values of COD,BOD and SS.

Sulfate and chloride

Sulfates and chlorides present in very high concentrations, 792 mg / l and 938mlg / l respectively these levels may be due because of the discharges are likely urban use based detergents sulfites (met stable state) that this transforms (oxidation) sulfate.

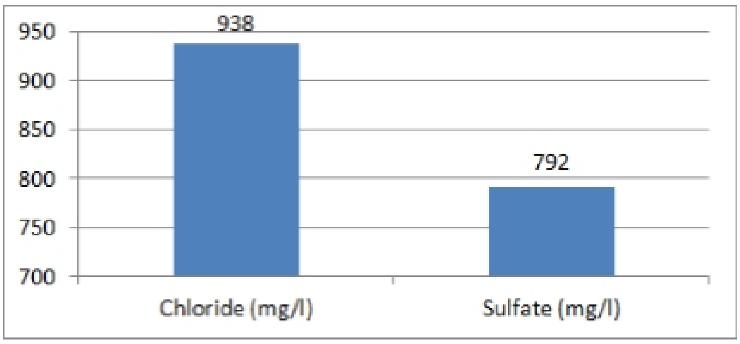


Figure 4. Values of sulfates and chloride.

Kjeldahl nitrogen (TNK) ammonium, nitrate and nitrite

Urine is the main indicator of the presence of nitrogen in urban waste water and detergent is ammonium, ammonification reactions may occur that transform organic nitrogen to ammonium NH4 + (reduced form of nitrogen), in fact the demand for oxygen by ammonia is very high they are molecules (nitrogen compound) odor causing odors. The maximum value of nitrate is 7.94 mg /l. The Kjeldahl nitrogen has concentrations alarming is the maximum observed in the rejection (62.18 mg /l), the values of the ammonium and nitrite are respectively 26.6 mg /l, 0.6mg /l.

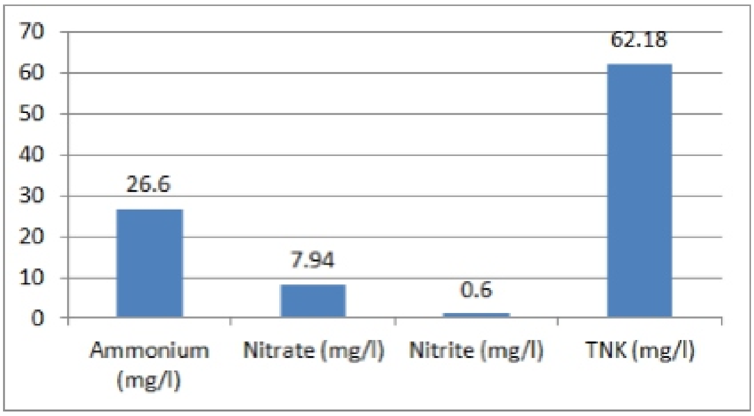


Figure 5. Values of ammonium, nitrate, nitrite and TNK.

CONCLUSION

The results of analysis of wastewater carried by the river of Bechar show the existence of a nitrogenous organic pollution, clearly shows that the technical standards required in sanitation was not respected at all levels. Regulation was not applied that indicates a degraded situation wastewater of the city, this degradation reveals that the city is facing a problem of pollution and nuisance mainly related to urban wastewater effluents without treatment.

The results obtained from the study physic-chemical analysis of samples of discharges (W) show that groundwater contamination by wastewater from the river by a process of infiltration depends on several environmental and climatic factors is very probable that urban waste treatment is essential to protect the water and the ecosystem.

There is much to do to stop the drift aquifers, groundwater and agricultural land, which will probably be polluted and have a solution to this problem can be used in solutions that address "the same time" to different levels and in different sectors such as the installation of pollution control systems (sewage, lagoon or settling basin) to reduce pollution and urban wastewater reuse in irrigation.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to the MESRS of Algeria, for the support.

REFERENCES

[1] AFNOR, French Association for Standardization. (1986). Water test methods. 2nd edition. Collection of French standards, Paris, France.

[2] AFNOR, French Association for Standardization. (1994). Collection of French standards: water quality. Environment, Paris, France.

[3] BENDIDA A, TIDJANI A, BADRI A, KENDOUCI M A and NABOU M. (2013) .Treatment of domestic wastewater from the town of Bechar by a sand filter (sand of Beni Abbes Bechar Algeria)", Energy Procedia ELSEVIER 36 (2013) 825-833

[4] DEGREMONT (1978) "technical water Memento", Eighth Edition, France

[5] FRANCK.R. (2002), Water analysis, regulatory and technical aspects. Scérén CRDP AQUITAINE Edition. Bordeaux, pp165-239.

[6] HAZOURLI S., L. BOUDIBA, ZIATI M. (2007), Characterization of wastewater pollution of the industrial area of Al-Hajar, Annaba. LARHYSS Journal, ISSN 1112-3680, No. 06, p. 45-55.

[7] KENDOUCI MOHAMED AMINE (2012). Development of local materials for wastewater pretreatment. Magister Thesis, University of Bechar, Algeria.

[8] LI ZHI-PINGG, CAO LIAN-HAI, CHEN XIAO-GANG, SHEN ZHAO-LI, ZHONG ZUP-SHEN,(2008). Influence on shallow ground water by nitrogen in polluted river, Desalination14 (2008) 103–108

[9] RODIER J. (2005)-The analysis of natural water, wastewater, water mer.8 the Edition technical DUNOD, Paris, pp. 1008-1043

Impact of Urbanization on Hydrological Responses and the Efficiency of Low Impact Development (LID) Implementation in Amman, Jordan

[1] H. F. Gammoh, [2] A. Y. Shamseldin

[1,2]Department of Water and Civil Engineering, University of Auckland, Auckland, New Zealand

E-mail: [1]hgam546@aucklanduni.ac.nz ,[2] a.shamseldin@auckland.ac.nz

ABSTRACT

Water scarcity is a continuing concern in Jordan which is currently experiencing the two contradictories: droughts and floods. This implies applying innovative solutions to manage storm water. The present paper investigates the efficiency of LID in mitigating urbanization impacts in Jordan. The performance of LID devices (infiltration trenches) was evaluated. The analysis was based on comparing the hydrological responses of a 500-hectare catchment located in Amman, in different scenarios using the software Personal Computer Storm Water Management Model (PCSWMM). The predevelopment conditions were compared with two hypothetical future settings of post-development with and without LID implementation. Results showed that the peak flow increased by 183% whereas the lag time was reduced by 78% when the level of urbanization increased from predevelopment conditions to 60%. However, by implementing LID devices, the predevelopment conditions could be partially restored. LID effectively controlled storms at smaller return periods (2, 5, and 10 years) while storms at higher return periods (25, 50 and 100 years) required more mitigation. Continuous modelling of historical rainfall data for the period (1990-2016) indicated the potential to manage approximately 80% of annual rainfall through infiltration trenches.

Index Terms - Hydrological Responses, LID, PCSWMM, Urbanization.

I. INTRODUCTION

As population continues to grow around the globe, natural resources are still limited. The most vulnerable natural resource is fresh water. The Middle East, in particular, has always struggled with water scarcity issues. The region started recently to experience two contradictories extreme events: droughts and floods [1]. Jordan is one of the countries facing serious challenges in the region. It is the fourth driest country in the world [2].

Jordan is witnessing a vast population growth due to hosting refugees from neighboring countries besides native people growth. This has resulted in the rapid urbanization of some areas to meet the demand for housing and infrastructure.

Urbanization is proved to affect hydrological responses of natural catchments. It reduces infiltration, baseflow and lag times, and at the same time, stormwater flow volumes, peak discharge, frequency of floods and surface runoff are dramatically increased [3].

Conventional stormwater systems lack the flexibility to accommodate urbanization impacts effectively [4]. Therefore, analysing the efficiency of Low Impact Development (LID) in building the resilience of Jordan to water challenges, both in terms of its scarcity and flooding, would be of much importance. LID is an evolving sustainable stormwater management philosophy. The main principle of this approach is to bring the hydrology of urban catchments closer to pre-development conditions [5]. LID combines planning and conservation strategies with decentralised distributed devices to manage stormwater runoff at source [4]. Examples of LID devices include rain gardens; green roofs; infiltration trenches; permeable pavement, and rain barrels. There is a growing body of literature that recognises the importance of LID. Chang et al. [6] assessed LID efforts and relevant governmental policies from a global perspective. They found that LID functions are well understood all over the world. However, it is not well incorporated in the design and planning of urban cities. Chang et al. [6] found that few countries that have framed relevant strategies and initiatives with the aim of promoting LID. These countries are mainly US, UK, Germany, Australia, New Zealand, Japan, China, Singapore, and Hong Kong. However, in the author's present knowledge, there are no initiatives for LID implementation in Africa and the Middle East countries which are considered to be the most water-stressed region in the world. Hydrological models have been widely used for assessing the impact of land use change on hydrological responses. The efficiency of LID devices is also assessed in these models. Kong et al. [7] used GIS-based SWMM to model and compare the changes in stormwater runoff characteristics among four different scenarios simulating urbanization and LID implementation in a new urbanized area in China. Their results confirmed the effectiveness of LID controls. Akhter & Hewa [8] evaluated the land use change impact in the Myponga catchment in Australia using PCSWWM. The study also investigated the possibility of implementing LID techniques to manage the resulting floods. They have found that urbanization had severe impacts on the catchment but using LID devices could effectively reduce the risk of flooding.Following the international trends, this paper adopts a similar modelling procedure to investigate the efficiency of LID in managing urbanization impact in Jordan.

II.METHODOLOGY

A. Data Collection & Study Area

The study area is located northeast of the center of Amman, the capital of Jordan. Increased urbanization is noticed in the adjacent area due to high native population growth and the increase of the numbers of refugees from neighboring countries because of the unstable political conditions in the region and especially the Syrian crisis [9]. The study area is chosen to be an undeveloped area as shown in Fig. 1. In the absence of an online database, access to reliable data was restricted. The Metrological Department, climate division in the Ministry of Water and Irrigation (MWI) was contacted to provide rainfall data. A historical record of daily rainfall readings for the period 1990 – 2016 was obtained for Amman-Airport Station (AL0019). The study area is located about 5 km southeast the station.

Fig. 1. Study area location

The hydrological responses of 500 hectares of undeveloped land are investigated. The 500-hectare catchment area was delineated from Digital elevation model (DEM) data using PCSWMM delineation tool. Analysis of the historical data showed that the average daily rainfall is about 6 mm/day while the average annual rainfall for this station is 232 mm/year. The rainy season is between October and May with more than 80% of the annual rainfall occurring November to February.

Intensity-Duration-Frequency (IDF) curves for the same area were obtained from a consultancy firm in Jordan for use in event-based modelling [10]

B. Predevelopment Conditions

The hydrograph of predevelopment conditions was obtained by analyzing the overland flow directions and accumulations. The predevelopment hydrograph would be the reference point for scenarios comparison. The catchment was discretized into sub-catchments using the delineation tool in PSCWMM. A total of 25 sub-catchments were created, and the natural streams were identified as shown in Fig. 2. The lowest point in the area is considered as an outfall.

Fig. 2. Catchment discretization

C. Conventional Stormwater Management

After studying the topography of the area, a traditional pipe network was designed to drain rainfall with the minimum possible disturbance of natural drainage patterns as shown in Fig. 3. The design followed the local standards that include retaining minimum and maximum flow velocities within recommended values, maintaining maximum spacing of junctions, allowing flow by gravity and minimizing deep trenching.

Fig. 3. Pipe network layout

D. LID Implementation

Low impact development (LID) practices are increasingly popular technologies for controlling runoff and managing stormwater. Nevertheless, the implementation of LID practices in arid and semi-arid regions is still ambiguous because it is difficult to justify the need for runoff control in such areas.

For a country such as Jordan, LID techniques can be used for rainwater harvesting and/or for enhancing groundwater recharge.Enhancing groundwater recharge is a vital need in Jordan because groundwater contributes about 54% of the total water supply. However, most aquifers are being over exploited [11]. Several LID devices were evaluated for relevant criteria such as the irrigation requirements, the ability for groundwater recharge and pollutant removal. Accordingly, the infiltration trench was selected for more investigation because of its ability to enhance groundwater recharge without any irrigation requirements. The use of other devices such as green roofs, vegetated swales, and bio-retention cells is restricted mainly by their irrigation requirements in dry seasons. Computer modeling is a very useful tool for the design and optimization of drainage and sewer systems. It also plays an important role in the evaluation of LIDs performance. In this study, two types of modelling procedures are used:

(1) Event-Based Modelling using PCSWMM (7.1). SWMM is a widely accepted tool for modelling the hydrological processes of a catchment. Despite the several advantages and applications of the model, it does not have any spatial interface. However, the commercial model PCSWMM combines GIS and US EPA SWMM 5, and offers a complete package for analysis of rainfall-runoff processes [8].

In this study, an event-based modelling was used to investigate the performance of a pipe network during a stormwater event that was extracted from available IDF curves. The primary aim of this study is to evaluate the urbanization impacts and the efficiency of implementing LID in mitigating the adverse effects of urbanization in Jordan. This was mainly done by comparing the predevelopment conditions of the study area with two hypothetical future settings:

S1: Post-development conditions with conventional stormwater management.

S2: Post-development conditions with a combination of conventional stormwater management and LID devices.

The present condition of the catchment was assumed to be undeveloped with zero impervious area. The effects of urbanization on the hydrological responses of the catchment were studied using different urbanization scenarios. Three future scenarios were hypothetically generated, namely, 20%, 40%, and 60% urbanization. LIDs were then designed and introduced to each sub-catchment to examine the efficiency of LID in managing runoff and enhancing groundwater recharge. It should be noted that the rainfall-runoff model was not calibrated or validated against observed values due to lack of data, as there is no gauging station in that area and actual measurements were not possible. However, the models' parameters were set to appropriate values based on the prevailing standards in Jordan and the author's experience. Therefore, the model is best used for comparing different scenarios and their relative changes resulting from urbanization and LID implementation.

(2) Continuous modelling of historical data (1990 – 2016) using Excel spreadsheets.

The main aim of time series continuous modelling is to characterize the long-term performance of LID devices which is of great significance in the planning, design, and operation. Fig. 4 presents a simple reservoir model used in the continuous modelling. The infiltration trench is assumed to receive stormwater runoff from an impervious area and drain the water in a constant infiltration rate. Spill over occurs when the reservoir is full, and evaporation losses were also accounted for in the model.

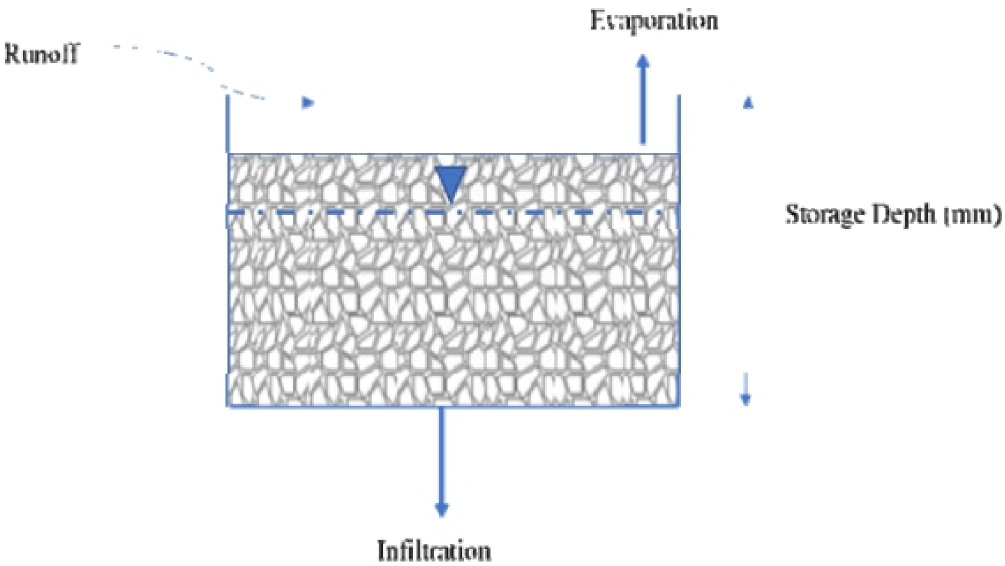


Fig. 4. Infiltration trench model

The model was run for 26 continuous years using a daily time step; the effectiveness of the infiltration trench was then measured by the average percentage of rainwater infiltrated annually through the LID unit.

III. RESULTS

A. Urbanization Impact

This study investigated the impact of urbanization on hydrological responses in three different scenarios where the percentage of impervious areas increased gradually. Hydrological responses such as surface runoff, infiltration, and lag times were analyzed.

Runoff is the integrated result of all meteorological and hydrologic processes in the catchment. Fig. 5 demonstrates how hydrographs change as urbanization increases from present predevelopment conditions to 60% urbanization. It is apparent from the figure that the urbanization intensifies peak flows significantly.

Table 1 shows the increase in peak flows and total runoff volumes, and the reduction in lag times and infiltration under different urbanization scenarios. Comparing with the predevelopment conditions, the peak flow had increased by 183% when the impervious area increased to 60%. The total runoff volume has also increased significantly while the lag time has dropped in the three scenarios. The reduction in infiltration is proportional to the increase in impervious area as also shown in table 1.

Table 1: Impact of urbanization on hydrological responses

Urbanization scenario	Increase in Peak flow	Increase in total runoff volume	Reduction in Lag time	Reduction in infiltration
20%	29%	35%	22%	20%
40%	108%	56%	73%	40%
60%	183%	75%	78%	60%

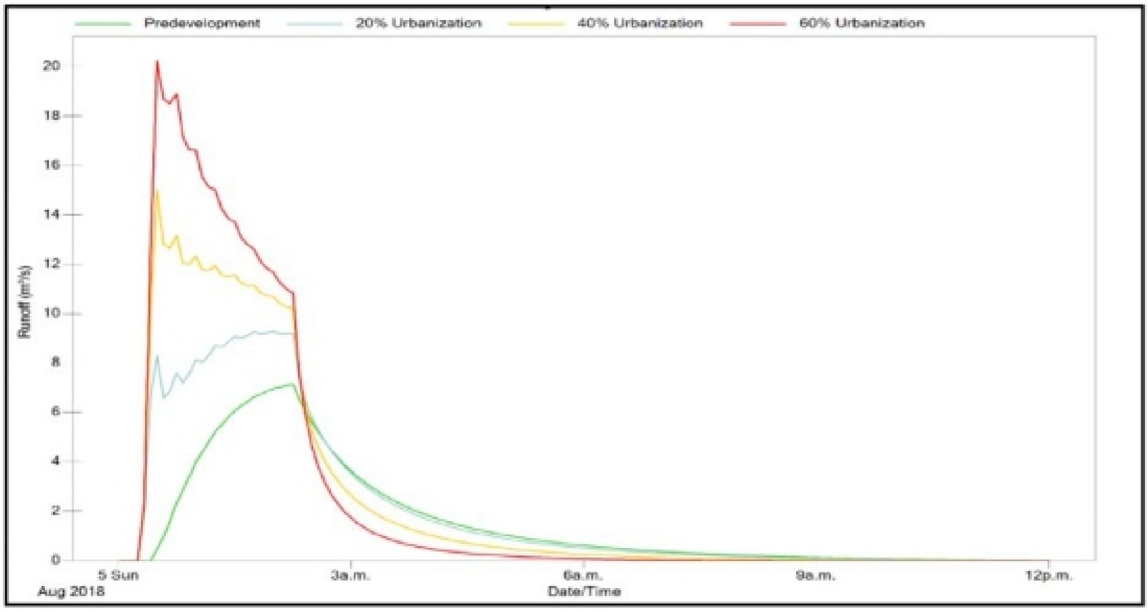


Fig. 5. Urbanization impact on catchment hydrographs

B. LID Impact

The infiltration trenches were designed and added to each of the sub-catchments. The trenches were attached in a way to receive all the runoff from 100% impervious area in each scenario.

Table 2 shows the impact of using infiltration trenches on the runoff volume, peak flow, lag times and infiltration under different urbanization scenario. Examination of the table shows that adding infiltration trenches to the different scenarios affected the hydrological responses of the system by bringing it back to the predevelopment conditions. The total runoff volume and the peak flow were partially restored while the lag times were fully restored to the predevelopment conditions.

Table 2: Impact of LID implementation on hydrological responses

Urbanization scenario	Reduction in Peak flow	Reduction in total runoff volume	Increase in Lag time	Increase in infiltration
20%	8%	20.30%	20%	19%
40%	47%	30.70%	75%	32%
60%	100%	40.60%	75%	47%

It is apparent that the infiltration trenches were effective in controlling the increase of peak flows and runoff volumes resulting from urbanization. It is worth mentioning that controlling the excess runoff in the 60% urbanization scenario without the use of LID required 23% increase in pipe diameters of the conventional drainage pipe network. This indicates the ability of LID techniques to reduce the size and cost of drainage systems and downstream control facilities. The infiltration trench is categorized as an "infiltration-based LID system". The predevelopment infiltration conditions were restored through continuous infiltration inside the trenches after the end of the rainfall event although the maximum infiltration rate has dropped significantly comparing to the predevelopment conditions.

The ability of infiltration-based techniques to restore hydrological processes has a lot of uncertainty and remains poorly understood. However, few recent studies noted the ability of infiltration-based techniques to restore and enhance the groundwater recharge after urbanization. Locatelli et al. [12] examined the impact of urbanization, with widespread artificial stormwater infiltration (soak wells), on groundwater levels and the water balance of a watershed. In their study, they used 40-year-long groundwater dataset for urban catchment located in Perth, Western Australia, as input data to a groundwater model. An increased recharge rate and decreased evapotranspiration were noticed, and the whole catchment water balance was affected by the performance of soak wells.

In order to study the long-term performance of infiltration trenches, continuous modelling was performed using the historical data record of Amman-Airport station. The model investigated the cumulative performance of an infiltration trench with different values of allowable storage depths in a unit catchment area.

Fig. 6 shows the performance of the infiltration trench measured by the percentage of infiltrated water for each design depth. A design depth of 600 mm is recommended for areas with rainfall patterns similar to the studied rain gage. The increase in infiltration trench depth beyond 600 mm could be considered unfeasible as no remarkable increase in the performance is achieved. There is a potential to infiltrate approximately 80% of rainfall annually to groundwater.

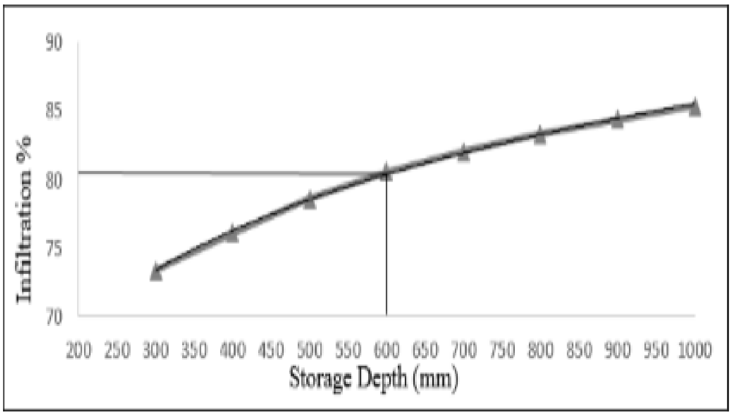


Fig. 6. Infiltration trench performance over the span period 1990 - 2016

LID techniques behaved differently for storms with different return periods. To study the behavior of infiltration trenches in managing runoff for larger storm events, the model was tested for storm events of larger return periods; 5, 10, 25, 50 and 100 years.

Fig. 7 depicts the effectiveness of infiltration trenches in managing storm events with different return periods. Inspection of the figure shows that the effectiveness of LID devices for controlling runoff volumes decreased for larger events demonstrating that LID worked better for small to medium floods while larger storms were not effectively managed. Nevertheless, there was always a considerable increase in the lag times and a substantial decrease in the runoff peaks of the catchment as shown in table 3 below.

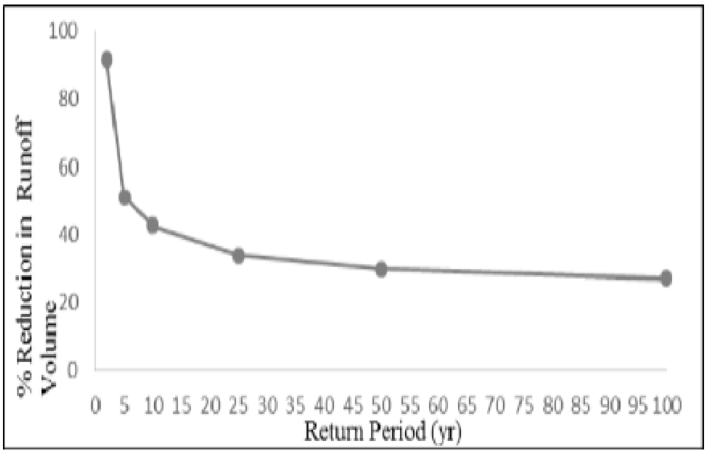


Fig. 7. Infiltration trenches performance vs return period

Table 3: Infiltration trench effectiveness for events with different return periods

Return Period	Reduction of total runoff volume	Reduction of runoff peak	Increase of lag time
5 Yrs	51.00%	61.30%	70.00%
10 Yrs	42.80%	56.30%	66.70%
25 Yrs	33.80%	52.00%	62.50%
50 Yrs	29.90%	49.10%	60.00%
100 Yrs	27.20%	47.90%	60.00%

CONCLUSION

In this paper, the urbanization impacts and the efficiency of LID techniques in mitigating these impacts in Jordan were investigated. It was found that urbanization has a tremendous impact on the hydrological responses. Infiltration and lag times are profoundly reduced leading to a significant increase in runoff peaks and volumes.

The infiltration trenches were effective in restoring the hydrological responses partially. LIDs effectively managed storms at smaller return periods (2, 5, and 10 years) while storms at higher return periods (25, 50 and 100 years) required more mitigation. Continuous modelling showed the high potential of infiltration trenches for controlling runoff and enhancing groundwater recharge. However, there are many uncertainties in the behavior of water under the ground. Therefore, further research is recommended to investigate the impact of infiltration trenches on groundwater levels separately and intensively over an extended period of time. Further research is also required to investigate the applicability of other types of LID devices under the topographic and metrological conditions in Jordan. Overall, it is concluded that LID techniques have considerable potential for runoff control in future development as part of sewer and stormwater management planning in Jordan. Even if used in conjunction with conventional stormwater systems, LID techniques can reduce the size and cost of drainage systems and downstream control facilities.

ACKNOWLEDGMENT

The authors would like to acknowledge the support of Computational Hydraulics International (CHI), Canada who provided a university grant to use PCSWMM for the current project.

REFERENCES

[1] World Bank. (2014). Climate change in the Middle East & North Africa. Retrieved from http://www.worldbank.org/en/programs/mena-climate-change

[2] Ministry of Water and Irrigation. (2016). Water sector capital investment plan 2016-2025. (National Water Strategy). Amman: MWI. Retrieved from https://jordankmportal.com/resources/water-sector-capital-investment-plan-2016-2025

[3] Du, J., Qian, L., Rui, H., Zuo, T., Zheng, D., Xu, Y., & Xu, C. -. (2012). Assessing the effects of urbanization on annual runoff and flood events using an integrated hydrological modeling system for Qinhuai river basin, China. Journal of Hydrology, 464-465, 127-139. Doi: 10.1016/j.jhydrol.2012.06.057
[4] Shamseldin, A. (2015). Stormwater onsite hydrologic mitigation. Auckland, New Zealand
[5] Eckart, K., McPhee, Z., & Bolisetti, T. (2017). Performance and implementation of low impact development – A review. Science of the Total Environment, 607-608, 413-432. Doi: 10.1016/j.scitotenv.2017.06.254
[6] Chang, N., Lu, J., Chui, T. F. M., & Hartshorn, N. (2018). Global policy analysis of low impact development for stormwater management in urban regions. Land use Policy, 70, 368-383. Doi: 10.1016/j.landusepol 2017.11.024
[7] Kong, F., Ban, Y., Yin, H., James, P., & Dronova, I. (2017). Modeling stormwater management at the city district level in response to changes in land use and low impact development. Environmental Modelling & Software, 95, 132-142. Doi: 10.1016/j.envsoft.2017.06.021
[8] Akhter, M., & Hewa, G. (2016). The use of PCSWMM for assessing the impacts of land use changes on hydrological responses and performance of WSUD in managing the impacts at Myponga catchment, South Australia. Water, 8(11), 511. doi:10.3390/w8110511
[9] Kumaraswamy, P. R., & Singh, M. (2017). Population pressure in Jordan and the role of Syrian refugees. Migration and Development, 6(3), 412-427.
[10] Enjicon Consultancy Firm, 2018, Personal communication, 3 April.
[11] Ministry of Water & Irrigation. (2015). Jordan water sector facts & figures. (). Amman, Jordan: Ministry of Water & Irrigation. Retrieved from http://www.mwi.gov.jo/sites/en-us/Hot%20Issues/Jordan%20Water%20Sector%20Facts%20and%20%20Figures%20 2015.pdf
[12] Locatelli, L., Mark, O., Mikkelsen, P., Arnbjerg-Nielsen, K., Deletic, A., Roldin, M., & Binning, P. (2017). Hydrologic impact of urbanization with extensive stormwater infiltration. Journal of Hydrology, 544, 524-537. Doi: 10.1016/j.jhydrol.2016.11.030

Acoustic Noise Loggers' Financial Analysis for Expanding their Coverage Over Montreal's Water Network

[1] Soliman Abu-Samra, [2] Ahmed Abdalmoujoud, [3] Tarek Zayed

[1,2,3]Ph.D. Candidate, Department of Building, Civil, and Environmental Engineering, Concordia University, 1515 Rue Sainte-Catherine O, Montréal, Canada.

[3]Professor, Dept. of Building and Real Estate (BRE), Faculty of Construction and Environment (FCE), The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

E-mail: [1]solimanamr_8@aucegypt.edu, [2]Ahmed.Abdalmoujoud@eng.asu.edu.eg, [3]tarek.zayed@polyu.edu.hk

ABSTRACT

Canada's water and wastewater infrastructures are at risk. The average water losses due to leaks are dramatically increasing where; they were estimated at 23% in the city of Montreal's water network. Therefore, early leak detection and repair will help in reducing those losses and keeping the water infrastructure sustainable and healthy. This paper aims at developing a decision-making model to assist municipalities in quantifying the potential financial benefits of expanding the acoustic noise loggers' coverage over the water network. The framework functions through the following models: (1) central database that contains information on the network characteristics; leaks; repair cost; surrounding conditions; (2) financial model that computes the capital and operational expenditures (CAPEX and OPEX) associated with purchasing and installing the acoustic noise loggers; (3) leak repair models that calculates the repair-associated cost; and (4) risk model that computes the probability and consequences of breaks for both systems. The outcome of the analysis displayed positive results in favor of expanding the coverage of the noise loggers with 26% financial savings over the study horizon. Even through, it seems to cost more at the first glance, when looking at the CAPEX and OPEX, but they do not highly contribute to the overall cost where; they only represent 21% from the overall cost. The developed models support the city in taking informed decision with respect to expanding the acoustic noise loggers' coverage.

Keywords - Aluminium Alloys, Plasma Spray, Thermal Barrier Coatings, Thermal Fatigue, Yttria-Zirconia.

I. INTRODUCTION

One billion individuals around the planet do not have access to clean drinking water (Krchnak 2016). Water distribution systems are highly susceptible to leaks, leading to water losses and potential breaks. The leaks contribute to 20% to 30% of the produced water losses in transmission networks (Cheong 1991), and in some systems, this loss can surpass 50% of the produced water (AWWA 2009). In areas with low maintenance for the water network, the leaks' contribution was estimated at 70% of the total water loss (Van Zyl and Clayton 2007). Water loss is not the only outcome of leaks, but they create problems at the social and environmental levels. For instance, 4 million holes into the UK roads' network are estimated to be opened to install pipes and repair water leaks. The overall cost of those damages is estimated at an annual cost of £7 billion (10,073,140,000 US$) divided into £1.5 billion

(2,158,305,000 US$) of direct damage costs, and £5.5 billion (7,914,500,000 US$) in social impact costs (Royal et al. 2011). Unattended leaks are susceptible to grow and thus allowing the introduction of pathogens and contaminants from the surrounding environment, which results in a major decrease of the water quality and causes harmful impacts on human life and other beneficiaries (Alkasseh et al. 2013). Network water loss is the water that never reaches its desired consumers through the distribution system. Consequently, it is essential to utilize an effective leak detection method for early leak detection and repair. However, given the fact that leak detection methods are costly and not all methods provide accurate information about the water network leaks along with their associated real water losses, it is important to carry out a financial analysis to trade-off the scenario of implementing more advanced leak detection methods versus traditional leak detection methods in terms of water losses savings and their associated costs, hidden costs behind the undetected leaks, etc.

International Leakage Index (ILI) was widely used as a performance indicator for real losses in a water network throughout the late 90s' and early 20s'. The main goal behind implementing advanced leak detection methods is minimizing the time required to detect a leak, and accordingly reduce the real water losses and avoid the occurrence of costly major breaks (Hardeman 2008). According to environment Canada report in 2011, the average water loss in water networks equals to 13% with the maximum value in Quebec with 21%. The main source of those water losses was the leaks in the water distribution network components. The early detection of leaks in the water network alongside with undertaking timely intervention actions before any unexpected failures in the network will attain several beneficial returns to municipality that can be summarized as follows: (1) reduce the life-cycle operating costs; (2) improve the intervention plans; (3) decrease the break occurrence risk and hence reduce the assets damage risk; and (4) increase the consumers' confidence in the water utility (Government of Canada 2017).

The damages and negative impacts drew the attention of researchers to help develop a real-time monitoring system within water main networks that allows early detection of leaks and eventually optimally-timed repairs. Multiple models were developed to address this issue. For instance, some scholars employed empirical analysis of the economic, environmental and social consequences of large-diameter water main failures to estimate their overall impact cost. The model aids in predicting the future water main failure consequences to enable risk-based, long-term capital improvement planning of water supply systems (Kalyan 2015). Other scholars evaluated new leak detection and measurement technologies to determine actual facility fugitive emission rates. The results of this study help the cities in evaluating the different leak detection technologies (Trefiak 2006). Another study was conducted to investigate the different leak detection technologies and quantify the benefits of installing acoustic leak detection technology. The investigation used state of the art noise correlation and computer correlation technology to survey the distribution system mains. The model displayed that 80% of the network had leaks and it showed that the leak detection equipment will enhance the network performance and decrease the number of leaks (Scolze and Maloney 1995). Finally, scholars developed a benefit-cost analysis for the leak detection. The study was implemented in New Mexico water systems and it showed the potential of real water savings. Even though, previous scholars developed leak detection models, they failed to (1) consider the leak propagation to visualize the leak advancement stages until the pipe breaks; (2) undertake a life-cycle cost analysis among different leak detection technologies to compute the potential financial benefits of early leak detection across the water network.

II.OBJECTIVES

This paper aims at developing a life-cycle costs analysis to investigate the potential financial benefits including both capital and operating expenditure (CAPEX and OPEX) behind expanding the coverage of the noise loggers leak detection system besides the manual detection system for early leak detection.

III. METHODOLOGY

The financial analysis model framework revolves through four phases as shown in Figure 1. The phases could be summarized as follows: (1) central database that incorporates the data provided by the city of Montreal as well direct and indirect costs; (2) direct costs financial model that computes the capital and operational expenditures (CAPEX and OPEX) of both the manual and noise loggers leak detection system; (3) life-cycle costing model that incorporates both leaks simulation model that simulates the different leak categories appearance among the different street categories as well as leaks repair model that computes the financial implications of the leaks in both the manual and noise loggers leak detections systems (i.e. repair cost, water losses, water losses costs, etc.);and (4) indirect costs financial model that computes the probability and consequences of breaks for different street categories.

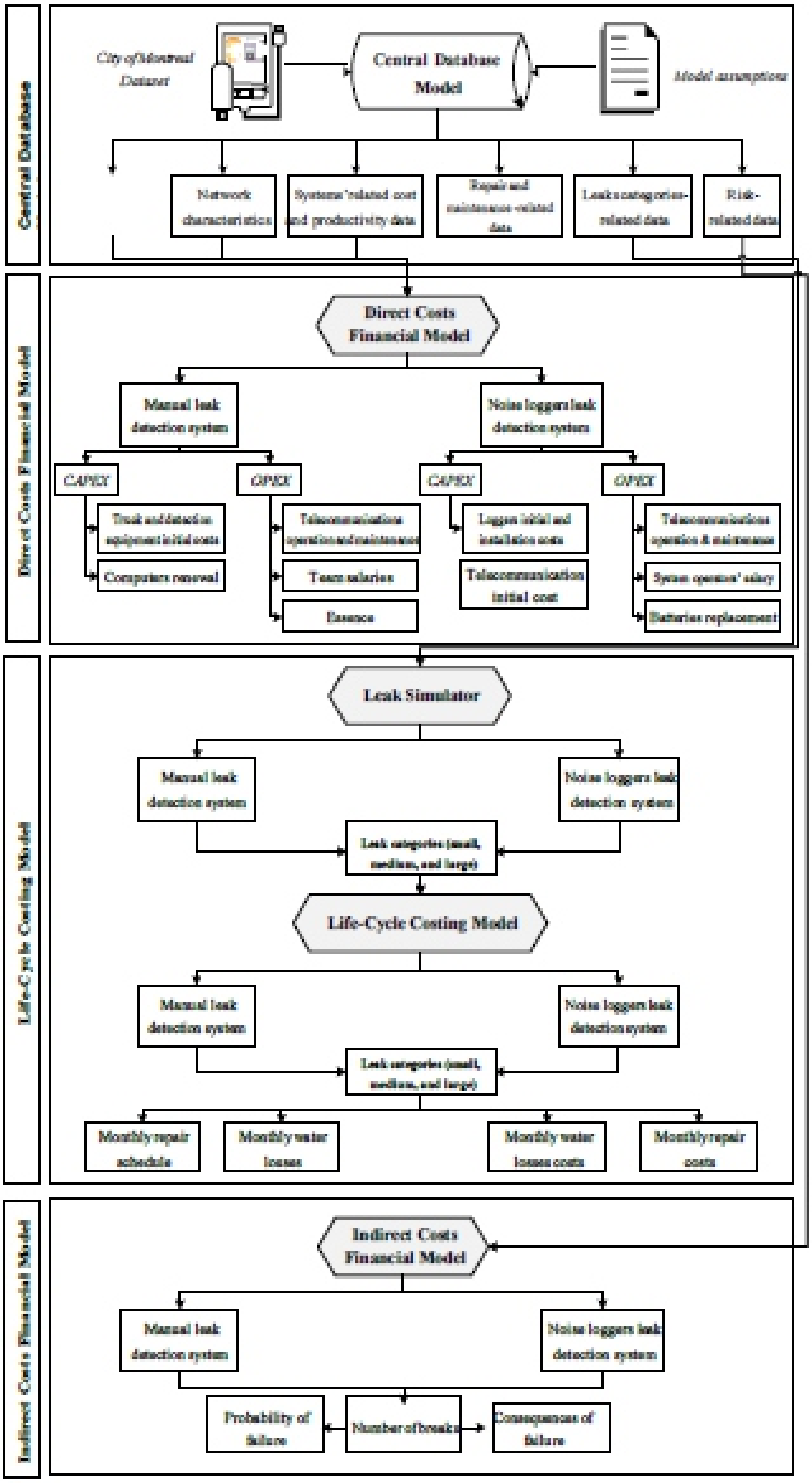


Fig.1. Methodology

The central database model is the foundation of the system that collects the different sources of data to build the B/C analysis. The direct costs financial model computes the capital and operational expenditures of both the manual and noise loggers leak detection system. It extracts all the systems' related data from the systems' related cost and productivity dataset. Those costs include the capital expenditures of loggers and telecommunications installation costs as well as the operating expenditures of telecommunication operating costs, system operators' costs, and batteries replacement costs.

The 3rd model is the life-cycle costing model that simulates the appearance of each leak category in the different street categories. It extracts the number of annual leaks for each leak category and the probability of detection from the leak categories- related dataset and the repair frequency, repair cost, repair time, and percentage repair for each street category from the repair and maintenance dataset. Then, based on the extracted data, it builds the leak simulation dataset for both the manual and noise loggers leak detection systems. Thenceforth, it computes the annual number of leaks per leak category per street category, based on both the total number of annual leaks and the percentage of each street category from the network under study. Hence after, depending on the leak detection system, it either computes the number of active and damaged noise loggers for the noise loggers leak detection system or extracts the probability of detection for the manual leak detection system. Afterwards, the life-cycle costing model is the heart of the analysis that computes the financialimplications of different leak categories on the street categories. It is built for both the manual and noise loggers leak detection systems, based on the desired coverage area of each system. Through a pre-set leak repair schedule, the model monthly calculates the water losses and their associated costs, repair costs per leak category within each street category. It extracts the information from three sources as follows: (1) monthly detected and undetected leaks for both the manual and noise loggers leak detection systems, which are extracted from the output of the leak simulation model discussed earlier, (2) repair frequency, percentage repair (%), and repair cost, which are obtained from the repair and maintenance-related dataset, and (3) average monthly water losses per leak category, and processed water unit cost, which is attained from the leak categories-related dataset. Then, based on the monthly detected leaks, repair frequency, and percentage repair (%), the model calculates the repair schedule across the study planning horizon for each leak category within each street category separately to account for the criticality of street/leak categories over others. Hence after, based on the repair schedule, the model determines the repair costs that are needed to successfully complete the leak repair. In parallel, based on the number of un-detected and un-repaired leaks, the model computes the amount of water losses and accordingly, based on the processed water unit cost, the water losses associated costs. Finally, the 4th model, indirect costs financial model computes the probability and consequences of failure for each street category and leak detection system. The model collects its' data from the risk-related dataset in the central database model and the outcome of the leak simulator, represented through annual number of unrepaired large leaks. Hence after, the direct, indirect, and life-cycle costs are added up to compute the annual and cumulative total costs across the study horizon as displayed in Equations 1 and 2.

$$TCi = DCiMS + DCiNL + LCCiMS + LCCiNL + ICiMS + ICiNL \quad \text{Eq. 1}$$

$$TC = \sum n \; TCi \quad \text{Eq. 2}$$

Where; TCiare the annual total cost ($); i is the age counter (years); DC are the direct costs ($); MS refers to the manual leak detection system; NL refers to the noise loggers leak detection system; LCC are the life- cycle costs ($);IC are the indirect costs ($); and TC are the cumulative total costs.

RESULTS AND DISCUSSION

To demonstrate the systems' functionality, the system was applied to 3,500 Km water network of the city of Montreal as displayed in Figure 2. The results of the proposed scenario (50% noise loggers network coverage) were compared to the baseline scenario (0% noise loggers network coverage) across 20 years planning horizon. The proposed scenario displayed $308 million over the planning horizon as opposed to $415 million over the planning horizon for the baseline scenario, which implies about 25% savings. Those costs include the systems' CAPEX and OPEX for noise loggers and manual leak detection systems; water losses' costs; leaks repair cost; and consequences of failure, resulting from the breaks that occurred either due to unrepaired or undetected large leaks. Furthermore, the distribution of the cost is displayed in Figure 3 where; the costs of the CAPEX, OPEX, water losses costs, leaks repair cost, and consequences of failure are $28 million, $37 million, $14 million, $223 million, and $5 million respectively. It is obvious that the leak repair cost contributes with 72%, followed by the OPEX, which contributes with 12%. Then, they are followed with the CAPEX, which contributes with 9%. In addition, the consequences of failure and the water losses costs are at the bottom of the list with about 5% and 2% respectively. This means that the extra spending on the CAPEX and OPEX for expanding the coverage of the noise loggers is a worthy investment, even if it costs more than the manual leak detection system. The reason why it is a worthy investment is because the extra cost paid on the system CAPEX and OPEX represents about 21% from the overall cost. However, the savings resulting from instantly detecting the leaks and thus repairing them, before reaching critical stages, is way more than the extra cost paid on the installation and operation of the noise loggers' leak detection system. Finally, the proposed scenario displayed around 13k leaks and 560 breaks over the planning horizon compared to 26k leaks and 4k breaks over the planning horizon for the baseline scenario, which implies about 57% savings. The more the number of leaks and breaks, the more time the leak repair team will put to repair them and more money accordingly, due to the high consequences of failures for repairing the leaks and breaks. Furthermore, the annual consequences of failure for the current scenario is estimated at $267k per year. However, the annual consequences of failure for the baseline scenario is estimated at $572k per year. Thus, the annual savings are estimated at $305k, which is about 53% savings. For the leak detection systems percentage contribution in the current scenario, the manual leak detection system resulted in $170 million over the planning horizon for the CAPEX, OPEX, water losses costs, leaks repair cost, and consequences of failure, compared to $139 million over the planning horizon for the CAPEX, OPEX, water losses costs, leaks repair cost, and consequences of failure of the noise loggers leak detection system, which implies that there are 18% savings in favor of the noise loggers leak detection system. The percentage contribution of the manual leak detection system is 55% compared to 45% for the noise loggers leak detection system. Thus, even though both systems are equally distributed over the network, the overall cost of the manual detection system exceeds the one of the noise loggers leak detection system by about $31.2 million over the planning horizon. This is due to extremely high leaks repair and water losses' costs.

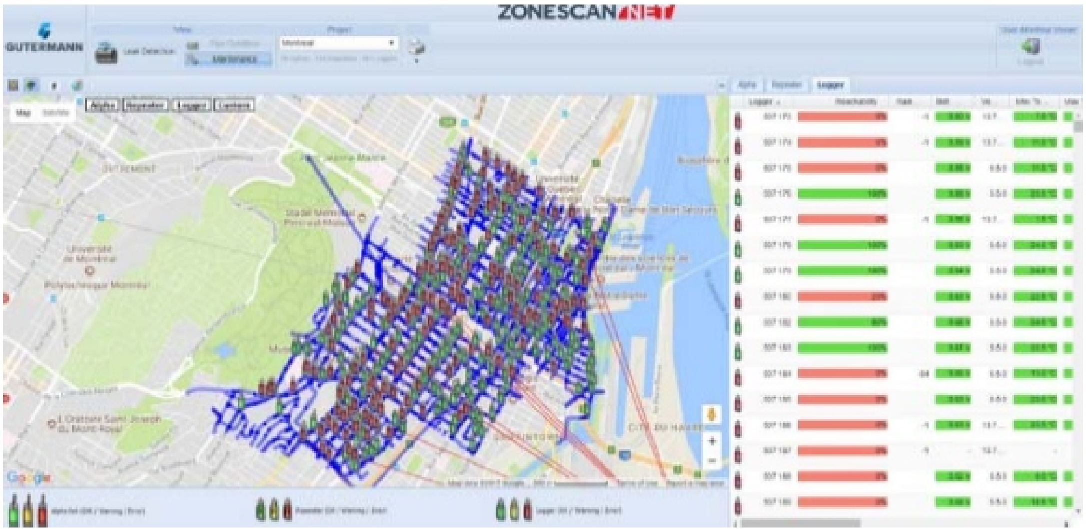


Fig.2. Noise loggers leak detection interface

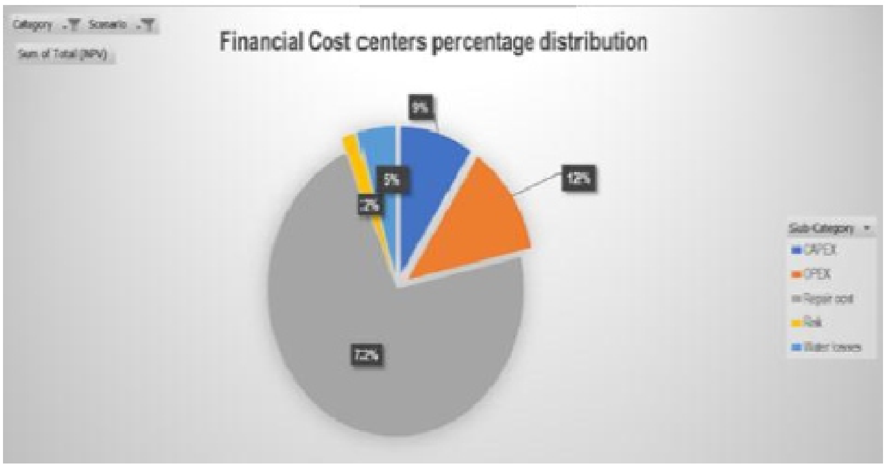


Fig.3Financial cost centers percentage distribution

CONCLUSIONS

In summary, the financial analysis showed that expanding the coverage of the noise loggersleak detection system is a worthy investment that will result in huge financial savings over 20 years planning horizon. Those savings were mainly due to the savings in the leaks repair cost, water losses cost, as well as consequences of failure where; their savings were estimated at $206.5, $17.5, and $6.7 million respectively. Even through, it seems to cost more at the first glance when looking at the CAPEX and OPEX, but they do not highly contribute to the overall cost where; they represent 21% from the overall cost. Thus, it is recommended to consider expanding the coverage of the noise loggers leak detection system over the city of Montreal water distribution network to detect the leaks in a timely manner and thus allow the leak repair teams to repair the leaks before they propagate and become a break.

ACKNOWLEDGMENTS

This research has been financially supported by the city of Montreal. The authors would like to show appreciation to Mr. Normand Hachey, the plan director of the city of Montreal, for his exceptional support and guidance throughout the study period.

REFERENCES

[1] Alkasseh, J. M. (2013). Applying minimum night flow to estimate water loss using statistical modeling: A case study in Kinta Valley, Malaysia. Water resources management, 27(5), 1439 - 1455.

[2] AWWA. (2009). Water loss control. Retrieved from American Water Works Association (AWWA): https://www.awwa.org/resources-tools/water- knowledge/water-loss-control.aspx?ItemNumber=48511

[3] Cheong, L. C. (1991). Unaccounted for water and economics of leak detection. Proc. International Water Supply Congress and Exhibition (pp. 11 - 16). Copenhagen: International Water Supply Association.

[4] Government of Canada. (2017). Residential water use in Canada. Retrieved from Government of Canada: https://www.ec.gc.ca/indicateurs- indicators/default.asp?lang=en&n=7E808512-1

[5] Hardeman, S. (2008, 12). A Cost-Benefit Analysis of Leak Detection and the Potential of Real Water Savi gs for New Mexico Water Systems. Thesis Dissertation. Albuquerque, New Mexico, Mexico: The University of New Mexico.

[6] Kalyan, R. P., Sreeganesh, R. Y., Sepideh, Y., Jinsung, C., Dan, K., & John, C. M. (2015). Empirical Analysis of Water- Main Failure Consequences. International Conference on Sustainable Design, Engineering and Construction. 118, pp. 727 - 734. Elsevier.

[7] Krchnak, K. (2016). Water scarcity. Retrieved from The water project: https://thewaterproject.org/water-scarcity/ Royal, A., Atkins, P. R., Brennan, M. J., Chapman, D. N.,

[8] Chen, H., Cohn, A. G., . . . Rogers, C. D. (2011). Site Assessment of Multiple-Sensor Approaches for Buried Utility Detection. International Journal of Geophysics, 1 - 19.

[9] Scholze, R. J., & Maloney, S. (1995). Comprehensive leak detection survey and benefit/cost analysis. World energy engineering congress and the 4th environmental technology congress and expo (pp. 640 - 648). Atlanta: Association of Energy Engineers.

[10] Trefiak, T. (2006). Pilot Study: Optical Leak Detection & Measurement. Conoco Phillips.

[11] Van Zyl, J. E. (2007). The effect of pressure on leakage in water distribution systems. Proceedings of the Institution of Civil Engineers - Water Management, (pp. 109 - 114).

Evaluation of Response Reduction Factor of Elevated Storage Water Tank under the Hydrostatic Pressure

[1] Apurva V., [2] Simon J.

[1]PG Student, Structural Engineering, Vellore Institute of Technology, Vellore, India

[2]Assistant Professor, Department of Structural Engineering, Vellore Institute of Technology, Vellore, India E-mail: [1]vibhuteapurva@gmail.com

A B S T R A C T

Whereas seismic design based on deformations is a concept that is gaining ground existing codes are fundamentally force-based, with a final check on deformation. A central feature of force-based seismic design is the response modification factor(R). The response modification factor plays a key role in the seismic design of the structure. To date, the values assigned to this factor are based on engineering judgment and have little sound technical basis. Any improvement in the reliability of modern earthquake resistant structure will require the systematic evaluation of the response characteristics that most affect values assigned to the factor. Currently, R factor assigned is based on several assumptions that are for regular structures. The R factor depends on ductility factor, over strength factor, structural redundancy and damping associated with structure. Thus this study sims to evaluate and compare the response modification factor for overhead water tank and water tank with varying staging height and seismic zone for tank full, tank empty and partially filled condition.

Keywords - Response Modification Factor, Seismic Design, Elevated Water Tank.

I. INTRODUCTION

WATER TANK

An earthquake have a major effect of devastating on infrastructure as well as lifeline. Seismic safety of liquid storage tank is of considerable importance. Elevated water tanks are critical structures which are expected to keep functional after severe earthquakes. Water storage tank should remain functional in post-earthquake period to ensure water supply. There are limited researches are done in investigating nonlinear seismic response of RC framed elevated water tank. This studies present systematic approach to evaluate response modification factor of elevated water tank sizes adopted in industry. Influence of various parameters i.e. seismic zone, fundamental period, height to diameter ratio, water condition in tank (full filled, partially, and empty) and tank size are studied.

II.RESPONSE MODIFICATION FACTOR

In design nonlinear structural response is not incorporated though response modification factor have integrated effect over it. Different codes mentioned different values of response modification factor depending upon type of structure. Response modification factor decreases the seismic force incorporating with the nonlinearity by using ductility, overstrength and redundancy. „R‟ factor is defined as the ratio of forces those would develop under specified ground motion if the structure were to behave entirely elastically to the code specified design forces The concept of „R‟ factor is based on the observations that well detailed seismic framing systems can sustain large inelastic deformation without collapse and have excess of lateral strength over design strength.

Strength Factor (Rs):

The strength factor (Rs) is measured as the ratio of maximum base shear capacity (Vu) to the design base shear (Vd).

Ductility Factor (Rμ):

Ductility ratio (μ) is defined as the ratio of maximum displacement to the yield displacement.

Redundancy Factor (Rr):

RC structural systems with multiple lines of lateral load resisting frames are normally considered as redundant structure, as each of the seismic frames is designed to transfer the seismic forces to the soil. It is taken as 1 in this study.

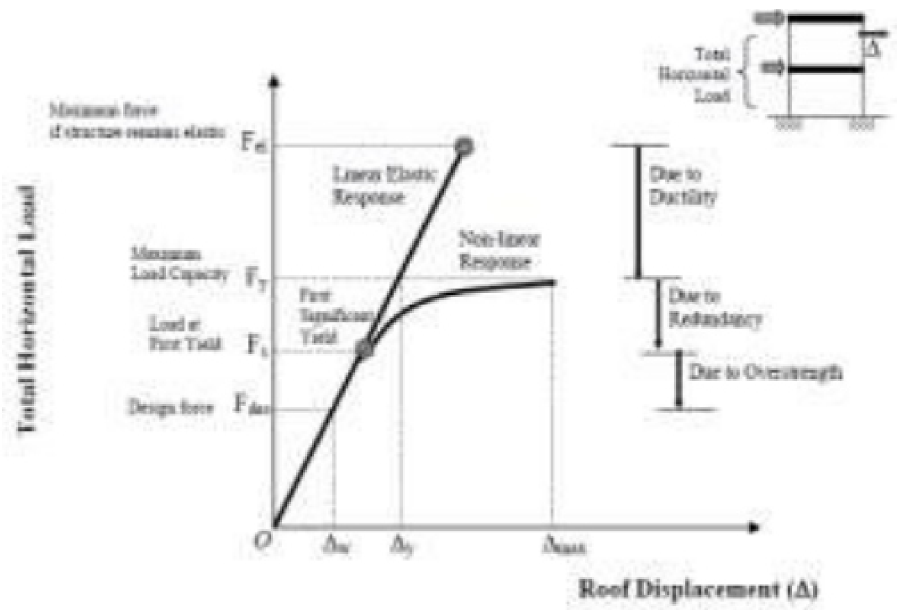


Fig. 1. Component of 'R'

$$R = RS * RR * R\mu$$

III. DESCRIPTION OF THE WATER TANK

A detailed description of our structure(Fig.1). The structure consist of circular RC framed elevated water tank supported by six number of column with capacity 1000 m3 and different staging height such as 12.5m, 15m, 17.5m for water condition full filled, partially filled and empty. Total mass of liquid is divided into two parts, i.e., impulsive mass & convective mass. The grade of concrete is M40 and steel is Fe500 is adopted. Structural massms, consist of container massand one-third staging mass. Mass of container comprises of mass of container wall, roof slab, floor beams, and floor slab. Damping in convective mode for all liquid types and for all tanks shall be taken as 0.5% of critical. Damping in the convective mode for all liquid types and for all tanks shall be taken as 0.5% of critical.

IV. MODELLING IN SAP2000

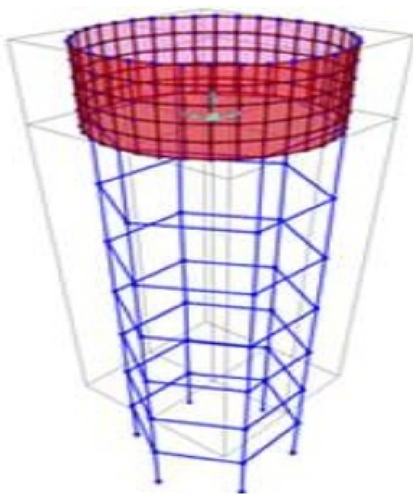


Fig 2. Model of water tank

V. MATERIAL PROPERTIES

Properties	Concrete	Steel
Grade	M40	fe500
Modulus Of Elasticity	27.386 N/mm2	200000 N/mm2
Density	$2.5\text{x}10^{-5}$ N/mm3	$7.85\text{x}10^{-5}$N/mm3
Poisson's Ratio	0	0.3

Table 1. Material Properties

VI. NONLINEAR STATIC EQUIVALENT ANALYSIS: PUSHOVER ANALYSIS

The need for a simple method to predict the non- linear behaviour of a structure under seismic loads saw light in what is now popularly known as the Pushover Analysis (PA). It can help demonstrate how progressive failure in buildings really occurs, and identify the mode of final failure. Putting simply, PA is a non-linear analysis procedure to estimate the strength capacity of a structure beyond its elastic limit (meaning Limit State) up to its ultimate strength in the post-elastic range. In the process, the method also predicts potential weak areas in the structure, by keeping track of the sequence of damages of each and every member in the structure (by use of what are called „hinges" they hold).

VII. SAMPLE CALCULATION OF 'R'

Over strength factor (Rs) =

maximum base shear capacity (Vu)

design base shear (Vd).

= 534.4= 1.12

474

Ductility Factor ($R\mu$) = $\frac{\text{maximum displacement } (\Delta u).}{\text{yield displacement } (\Delta\alpha)}$ =

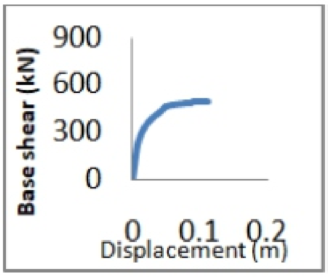
$= \frac{0.1}{0.0223}$

= 4.73

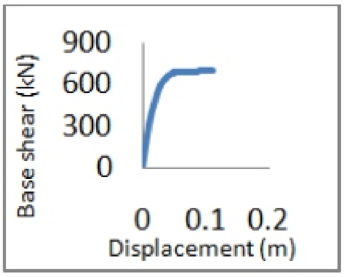
Redundancy Factor (Rr) = 1 R = 1.12 x 4.73 x 1= 5.29

VIII. SIMULATIONS AND ANALYTICAL RESULTS

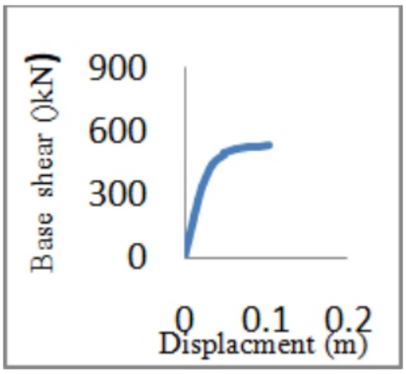
Result of pushover analysis for staging height 12.5m for Zone- II



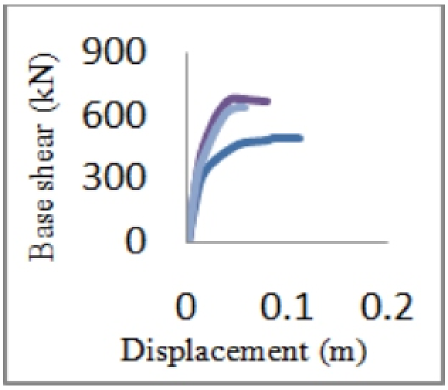
Tank empty condition



Tank partial condition

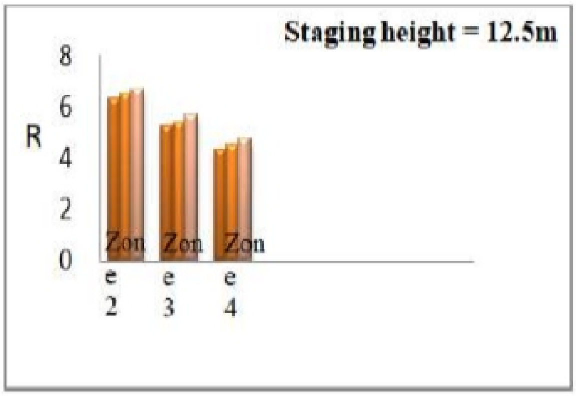


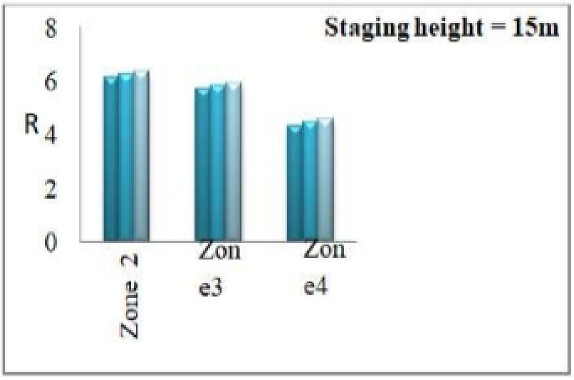
Tank full condition

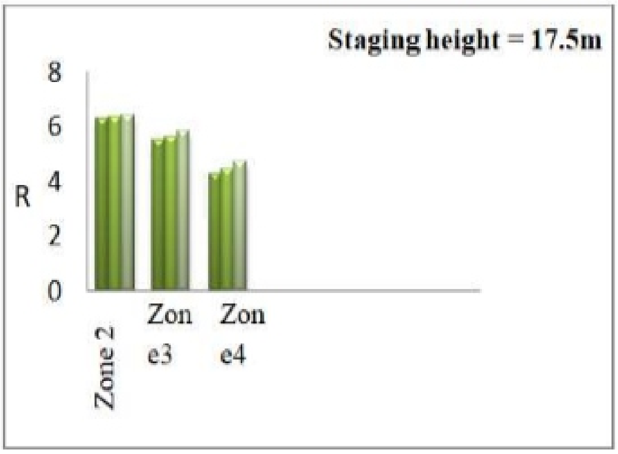


Combinaton of tank empty, Partial, full condition

IX. COPMARISON BETWEEN 'R' AND SEISMIC ZONES







X. CONCLUSION

The overstrength and ductility factor were calculated based on pushover curves and the effect of various parameters such as fundamental period, height to diameter ratio, seismic design zone, and tank size on the seismic response factors of elevated water tanks was studied.

The results of the study showed that shorter tanks demonstrate lower maximum base shear (V_{max}) comparing to taller tanks.

Ductility factor is not significantly influenced by the seismicity level as it is mainly a function of geometry and material properties of the structure.

R of RC elevated water tank is compared for different water condition such as tank full filled, partial filled, half filled.

It is concluded that for empty tank has lower R value than partially filled, and partially filled has lower value than full filled water tank.

It is also concluded that for increasing height of water tank R values also increases. And for increasing seismic zones R value goes on decreasing.

REFERENCES

[1] Fotini D. Konstandakopouloua, George D. Hatzigeorgioub, "Water and wastewater steel tanks under multiple earthquakes,Earthquake Engineering" 100 (2017) 445–453.

[2] R. Ghateh a, M.R. Kianoush a, W. Pogorzelski b, "Seismic response factors of reinforced concrete pedestal in elevated water tanks", Engineering Structures 87 (2015) 32–46.

[3] Chunfeng ZhaoJianyun Chen, Na Yu,"Dynamic response of AP1000 water tank with internal ring baffles under earthquake loads"Energy Procedia 127 (2017) 407–415.

[4] SoheilSoroushnia, Sh. TavousiTafreshi, "Seismic Performance of RC Elevated Water Tanks with Frame Staging and Exhibition Damage Pattern"Procedia Engineering 14 (2011) 3076–3087

[5] Lamia AitL"Hadj, HocineHammoum, "Nonlinear analysis of a building surmounted by a reinforced concrete water tank under hydrostatic load" Advances in Engineering Software 117 (2018) 80–88

[6] M. Moslemia, M.R. Kianoush W. Pogorzelski, "Seismic response of liquid-filled elevated tanks"Engineering Structures 33 (2011) 2074–2084.

Instructions for Authors

Essentials for Publishing in this Journal

1 Submitted articles should not have been previously published or be currently under consideration for publication elsewhere.

2 Conference papers may only be submitted if the paper has been completely re-written (taken to mean more than 50%) and the author has cleared any necessary permission with the copyright owner if it has been previously copyrighted.

3 All our articles are refereed through a double-blind process.

4 All authors must declare they have read and agreed to the content of the submitted article and must sign a declaration correspond to the originality of the article.

Submission Process

All articles for this journal must be submitted using our online submissions system. http://enrichedpub.com/ . Please use the Submit Your Article link in the Author Service area.

Manuscript Guidelines

The instructions to authors about the article preparation for publication in the Manuscripts are submitted online, through the e-Ur (Electronic editing) system, developed by **Enriched Publications Pvt. Ltd**. The article should contain the abstract with keywords, introduction, body, conclusion, references and the summary in English language (without heading and subheading enumeration). The article length should not exceed 16 pages of A4 paper format.

Title

The title should be informative. It is in both Journal's and author's best interest to use terms suitable. For indexing and word search. If there are no such terms in the title, the author is strongly advised to add a subtitle. The title should be given in English as well. The titles precede the abstract and the summary in an appropriate language.

Letterhead Title

The letterhead title is given at a top of each page for easier identification of article copies in an Electronic form in particular. It contains the author's surname and first name initial .article title, journal title and collation (year, volume, and issue, first and last page). The journal and article titles can be given in a shortened form.

Author's Name

Full name(s) of author(s) should be used. It is advisable to give the middle initial. Names are given in their original form.

Contact Details

The postal address or the e-mail address of the author (usually of the first one if there are more Authors) is given in the footnote at the bottom of the first page.

Type of Articles

Classification of articles is a duty of the editorial staff and is of special importance. Referees and the members of the editorial staff, or section editors, can propose a category, but the editor-in-chief has the sole responsibility for their classification. Journal articles are classified as follows:

Scientific articles:

1. Original scientific paper (giving the previously unpublished results of the author's own research based on management methods).

2. Survey paper (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution visible through his self-citation);

3. Short or preliminary communication (original management paper of full format but of a smaller extent or of a preliminary character);

4. Scientific critique or forum (discussion on a particular scientific topic, based exclusively on management argumentation) and commentaries. Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);
2. Informative contribution (editorial, commentary, etc.);
3. Review (of a book, software, case study, scientific event, etc.)

Language

The article should be in English. The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and Summary

An abstract is a concise informative presentation of the article content for fast and accurate Evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to 250- Word abstract should be placed between the title and the keywords with the body text to follow. Besides an abstract are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract).

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

Acknowledgements

The name and the number of the project or programmed within which the article was realized is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programmed.

Tables and Illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

Citation in the Text

Citation in the text must be uniform. When citing references in the text, use the reference number set in square brackets from the Reference list at the end of the article.

Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.
The article should be accompanied with a cover letter with the information about the author(s): surname, middle initial, first name, and citizen personal number, rank, title, e-mail address, and affiliation address, home address including municipality, phone number in the office and at home (or a mobile phone number). The cover letter should state the type of the article and tell which illustrations are original and which are not.

<u>Address of the Editorial Office:</u>

Enriched Publications Pvt. Ltd.
S-9,IInd FLOOR, MLU POCKET,
MANISH ABHINAV PLAZA-II, ABOVE FEDERAL BANK,
PLOT NO-5, SECTOR -5, DWARKA, NEW DELHI, INDIA-110075,
PHONE: - + (91)-(11)-45525005

Note