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Desalination and Water Treatment
www.deswater.com
doi:10.5004/dwt.2017.21298

87 (2017) 209–215
August

Modelling and sensitivity analysis of varying roughness effect on dispersion coefficient: a laboratory study

I.T. Tenebe*, A.S. Ogbiye, D.O. Omole, P.C. Emenike

Department of Civil Engineering, Covenant University, Ota, Ogun State, Nigeria, email: yoshearer@gmail.com, imokhai.tenebe@covenantuniversity.edu.ng (I.T. Tenebe), ade.ogbiye@covenantuniversity.edu.ng (A.S. Ogbiye), david.omole@covenantuniversity.edu.ng (D.O. Omole), praisegod.emenike@covenantuniversity.edu.ng (P.C. Emenike)

Received 30 January 2017; Accepted 7 August 2017

ABSTRACT

Frequent disposal of effluent in rivers or streams in vicinity where the inhabitants rely majorly on it for domestic and agricultural purposes is dangerous, and that makes it relevant for precise modelling of dispersion coefficient or dispersion number. This will reduce under-estimation and over-estimation of this parameter as well as reduce frequent pollution assessment which have proven not to be sustainable. However, obtaining a model that will include all required parameter is still in process. This study considered the effect of varying roughness—which is the true nature of streams and rivers and its effects on the estimation of dispersion coefficient. It revealed that when varying roughness is increased by 1-unit, there will be an increase in dispersion number by 0.693 (t-statistics = 4.278; $p < 0.05$. In addition, an increase in 1-unit in the dispersion number value will require a decrease of both DO (t – ratio = –7.802; $p < 0.05$) and velocity (t – ratio = –4.992; $p < 0.05$) by 0.316 and 0.687 respectively. Sensitivity analysis further showed that roughness (K), dissolved oxygen (DO) are pertinent variables to be considered when dispersion co-efficient is to be modelled and have been previously left out. Furthermore, the ECM model generated, with $R^2 = 0.98$, *prob*(*F–statistics*) < 0.005 and Durbin-Watson t-statistics of 2.107 respectively shows statistical significance of the model. Hence, it is suggested that varying roughness or roughness and DO should be introduced in dispersion coefficient or dispersion number models to improve its accuracy.

Keywords: Dispersion number; Dissolved Oxygen; Error correction method (ECM); Pollution; Tracer studies

1. Introduction

Surface water—streams and rivers, are susceptible to constant pollution if not controlled as it is perceived by some people as a conduit for the transport of waste, and that it cleanses itself as dilution and dispersion takes place downstream. However, most people are ignorant on the possible harm these pollutants present in the river can cause to the users downstream as it is utilized for irrigation and domestic purpose among other uses [1]. This indicates that obtaining water of good quality for our basic and daily needs could be difficult thereby making water an at-risk commodity [2]. To circumvent this, there is a need for river or stream monitoring to help reduce local pollution. This will help to quickly identify if there are any significant changes in the current river ecosystem characteristics when threatened adversely, also to improve the general health status of the river and to come up with auspicious policies for proper river management—as in the case of the Water Framework Directive in 2000 [3]. For laboratory [4,5] or field study [3,6,7] purposes, trace studies (TS) using common salt as pollutants have been relatively and effectively used to mimic its transport in streams or rivers. Generally, it is understood that when tracers—irrespective of the type are released, the tracer is first diluted, thereafter, mixing occurring within the length and breadth of the channel or river and finally, the tracer transport process is completed by longitudinal dispersion [3,8,9]. The proper measurement of this parameter will provide a proper understanding—estimating and predicting, in the

*Corresponding author.

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