PHTHALIC ACID ESTERS IN URBAN WATERCOURSES OF COLOMBO AND THEIR TREATMENT

Ushetti Arachchi Appuhamilage Gimhani Danushika

(178059 P)

Degree Master of Science

Department of Civil Engineering

University of Moratuwa
Sri Lanka

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DECLARATION

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Name of the supervisor: Prof. M.W. Jayaweera

Signature of the supervisor: ***UOM Verified Signature*** Date: 27

The above candidate has carried out research for the Masters thesis under my supervision.

Name of the co-supervisor: Prof. N.J.G.J Bandara

Signature of the supervisor: ***UOM Verified Signature*** Date: 27/12/19

The above candidate has carried out research for the Masters thesis under my supervision.

Name of the co-supervisor: Prof. J. M. A. Manatunge

Signature of the supervisor: ***UOM Verified Signature*** Date: 27/12/2019

Abstract

Urbanization of many cities with industrial, commercial, and residential areas in the world takes place at an unprecedented scale. Di-2 Ethylhexyl Phthalate (DEHP) is commonly used as a plasticizer in a number of industries which has become a precursor to cause DEHP contamination of watercourses through untreated or partially treated industrial wastewater effluents. Such contamination may result in bioaccumulation and bio-concentration in biota, so that it will adversely affect humans through the food chains. The presence of six PAEs (dimethyl phthalate (DMP), diethyl phthalate (DEP), di (n-butyl) phthalate (DBP), benzyl butyl phthalate (BBP), bis(2-ethylhexyl) phthalate (DEHP), and di(n-octyl) phthalate (DnOP)) in 22 shallow urban watercourses in Colombo and suburbs of Sri Lanka was investigated and the effect on fish community was analyzed. EPA 8061A method was used in analyzing PAE concentrations in samples and Gas Chromatography / Mass Spectrometer was used.

Titanium dioxide (TiO_2) and Modified Coal-derived Fly Ash (MCFA) were successfully synthesized and characterized using Fourier–Transform Infrared Spectroscopy, Environmental Scanning Electron Microscopy, and X–ray diffraction. Effectiveness and efficiency of TiO_2 and MCFA in the removal of DEHP from wastewaters was identified.

According to the results obtained, the average concentrations of DEP, DBP, BBP, and DEHP in all watercourses varied between 2.5–265.0, 1.0–32.0, 61–108, and 12–165 μg/L, respectively. DMP and DnOP values were below the limits of quantification (DMP-0.5 μg/L, DnOP-1.0 μg/L) for all watercourses. DEHP was the most abundant PAE in many watercourses. The significant factors affecting the ubiquitous presence of PAEs in watercourses are the inherent properties of each PAEs, the presence of industrial and household products with great potential for the migration of PAEs in the sub-catchments, and the quality of receiving water. The contamination levels of PAEs in most of the watercourses are alarmingly high, as evidenced by higher concentrations of DEHP and DBP than those of Canadian permissible levels for the protection of aquatic life (16 and 19 μg/L).

Isolated lakes which are not adjoining to urban industries, showed depleted adverse effects, most of the urban lakes were observed a significant potential for adverse effects on fish. Thus, the ecological risk of PAEs in urban watercourses in Sri Lankan environments should be considered.

TiO_2 nanoparticles were used to remove DEHP through photocatalysis. The photocatalysis with TiO_2 for the destruction of DEHP was found to be a promising technique in removing DEHP from industrial wastewaters. The most economical dosage of TiO_2 would be one gram and it needs to be photocatalysed for a period greater than 44 minutes for complying with the permissible level stipulated for DEHP (16 μg/L) for the protection of aquatic life. The cost of the photocatalysis with TiO_2 was around Rs.120 and the cost could be further reduced when the material (TiO_2) is reused for subsequent usage. Even TiO_2 was reused for five times, inherent properties for photocatalysis were not changed.

An initial level of 171 μg/L of DEHP was successfully removed with 98% efficiency by three grams of MCFA dosage and consequently, regenerated with NaOH twice for the effective use. The maximum monolayer adsorption capacity of MCFA was 63.6 μg/g of DEHP. MCFA is a potential candidate for the effective removal of DEHP from industrial wastewaters as its raw materials are readily available.

Key words: Adsorption, Phthalate Acid Esters, TiO_2, MCFA, Photocatalysis

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LIST OF ABBREVIATIONS

Abbreviation	Description
PAEs	Phthalic Acid Esters
DEHP	Bis(2-ethylhexyl) phthalate
DBP	Di(n-butyl) phthalate
DMP	Dimethyl phthalate
DEP	Diethyl phthalate
BBP	Benzyl butyl phthalate
DnOP	Di(n-octyl) phthalate
USEPA	United States Environmental Protection Agency
MCL	Maximum Contaminant Level
PVC	Polyvinyl Chloride
PET	Polyethylene terephthalate
TiO_2	Titanium dioxide
MCFA	Modified Coal-derived Fly Ash
DiBP	Diisobutyl phthalate
CFA	Coal Fly Ash
GC/MS	Gas Chromatography/Mass Spectrometry
CH_2Cl_2	Dichloromethane
FT–IR	Fourier Transform – Infrared Spectroscopy
XRD	X–Ray Diffraction Spectroscopy
ESEM	Environmental Scanning Electron Microscopy
EDX	Energy-Dispersive X-ray Spectroscopy

LOD	Limit of Detection
LOQ	Limit of Quantification
RSD	Relative Standard Deviation
RQ	Risk Quotient
MEC	Measured Environmental Concentration
PNEC	Predicted No Effect Concentration
DI	Deionized
C	Carbon
Ti	Titanium
O	Oxygen
UV	Ultraviolet