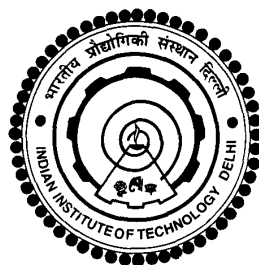


**MONITORING AND RISK ASSESSMENT OF
POLYAROMATIC HYDROCARBONS (PAHs) IN A
STRETCH OF RIVER GANGES**

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**DEPARTMENT OF CIVIL ENGINEERING
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by

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Submitted

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Certificate

This is to certify that the thesis entitled “**Monitoring and Risk Assessment of Polyaromatic Hydrocarbons (PAHs) in a Stretch of River Ganges in Kanpur**”, being submitted by **Ms. Pooja Srivastava**, to the **Indian Institute of Technology Delhi**, for the award of ‘**Doctor of Philosophy**’ in Department of Civil Engineering is a record of the bonafide research work carried out by her under our supervision and guidance. She has fulfilled the requirements for the submission of this thesis, which to the best of our knowledge has reached the requisite standard.

The material contained in the thesis has not been submitted in part or full to any other University or Institute for the award of any other degree or diploma.

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Abstract

In Indian scenario, very few studies have been done on environmental issues related to polyaromatic hydrocarbons. A number of PAHs are toxic, mutagenic and carcinogenic in nature. Trace amount of these compounds can pose significant ecological and human health risk. Objective of this research is to study status of PAHs in an Indian River, their sources and distribution, associated human health risk and possible control through biodegradation of PAHs. The results show the presence of PAHs in the stretch of river Ganges near Kanpur. Existing Common Effluent Treatment Plant (CETP) and a number of urban wastewater drains are acting as point sources of PAHs for the river. Water samples were collected from the river, CETP outlet and drains and analyzed using standard methods. Principle Component Analysis (PCA) and molecular ratio method were used to identify the possible sources. Partitioning of selected PAHs showed that after entering into the river PAHs gets distributed into dissolved, suspended and sediments. The partitioning of PAHs significantly varies with pH and amount of PAHs entering into the river. Ultrasonication method was used for the extraction of PAHs from suspension and sediments collected during this study. Human health risk due to possible exposure of PAHs present in river was also calculated. The non-carcinogenic chronic risk was calculated in the form of hazard index (HI) for all the selected sites for all the seasons. The results indicate the possibility of significant human health risk due to continuous discharge of PAHs in the river. As a part of the study feasibility of biodegradation of PAHs was explored through extended aeration in batch reactors. During this part of the study, sludge samples were collected from the effluent treatment plant of an oil refinery and was used as the inoculum. The extended aeration was found to be effective in changing the PAHs into other species.

The results of present work is expected to form a base for the environmental regulatory agencies in understanding the current status of PAHs in Indian River, drains, and CETP and associated human health risk and take necessary preventive and control measures.

Key words: ANOVA test, Biodegradation, Common effluent treatment plant, Human health risk, Hazardous index, Incremental lifetime cancer risk, Polyaromatic hydrocarbons, Wastewater, Principal component analysis, Ultrasonication.

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List of Abbreviations

ACN	Acetonitrile
ANOVA	Analysis of variance
Anth	Anthracene
ATSDR	Agency for Toxic Substances and Disease Registry
B(a)A	Benzo(a)anthracene
BaP	Benzo(a)Pyrene
B(b)f	Benzo(b)fluoranthene
B(g,h,i)P	Benzo(g,h,i)perylene
BIS	Bureau of Indian Standards
B(k)f	Benzo(k)fluoranthene
BOD	Biochemical Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
CETP	Common effluent treatment plant
Chry	Chrysene
COD	Chemical Oxygen Demand
DCM	Dichloromethane
GC/FID	Gas Chromatography/Flame Ionization Detector
GC/MS	Gas Chromatography/ Mass Spectroscopy
HDPE	High-density polyethylene
HMW	High Molecular Weight
HPLC-PDA	High Performance Liquid Chromatography-Photo Diode Array
HPLC/UV-VIS	High Performance Liquid Chromatography/Ultraviolet-Vissible
IARC	International Agency for Research on Cancer
ILCR	Incremental Life Time Cancer Risk
I(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene
IRIS	Integrated Risk Information System
LECA	Light weight expanded clay
LLE	Liquid-liquid Extraction
LMW	Low Molecular Weight

LPM	Litre per minute
MAC	Magnetic activated carbon
MEFs	Mutagenic Equivalent Factors
MLD	Million Litre per Day
MLSS	Mixed Liquor Suspended Solid
MOS	Margin of Safety
PAHs	Polycyclic Aromatic Hydrocarbons
PCA	Principal Component Analysis
PCs	Principal Components
Phen	Phenanthrene
POPs	Persistent organic pollutants
RBC	Rotating Biological Contractor
SPE	Solid Phase Extraction
SPM	Suspended Particulate Matter
TEF	Toxicity Equivalent Factor
TSPM	Total suspended particulate matter
UASBR	Upflow Anaerobic Sludge Blanket Reactor
USEPA	United State Environmental Protection Agency
UV	Ultra Violet
WHO	World Health Organization
WWTP	Waste water treatment plant

List of Notations

AT	Average lifespan
BaP _{eq}	Total BaP equivalent concentration
C	Average exposure concentration over the period
CDI	Chronic daily intake
CR	Contact rate, the amount of contaminated medium contacted per unit time
CSF	Carcinogenic slope factor of the ingested water
DA _{event}	Adsorbed dose per event
DAD	Dermally adsorbed dose
df	Degree of freedom
ED	Exposure duration
EF	Exposure frequency
EFD	Exposure frequency and duration, a variable that describes how long and how often exposure occurs
FA	Fraction adsorbed water
HI	Hazardous Index
HQ	Hazard Quotient
IR	Ingestion rate of water
K _H	Henry's law constant
K _{ow}	Octanol-water partition coefficient
K _p	Dermal permeability coefficient of compound in water
MS	Mean squares
R	Gas constant
RfD	Reference dose
SA	Skin surface area available for contact
SS	Sum of squares
TEF _i	Toxicity equivalent factor of PAH _i relative to BaP
t _{event}	Lag time per event
t _{event}	Event duration