Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment

Landfill Site selection and bioremediation of emerging contaminants in groundwater.

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Abstract

Groundwater is a primary source of water for a huge chunk of population in India. Groundwater contamination has been quite evident recently and one of the main reasons behind it is leaching of pollutants from un-engineered landfill.

Heavy metals, other toxins and PFOAs leach from household discards, food waste, plastics, paints, batteries, e-waste which is result of no source segregation.

This study is based on application of modern approaches like ArcGIS and multicriteria decision making tools (MCDM) for suitable landfill site selection considering various governing criteria influencing an objective and comparatively evaluates each of the criteria to obtain the best results in order to minimize the chances of percolation of pollutants into the groundwater.

Microbial bioremediation of these pollutants by bio-augmenting acclimatized microorganisms for their onsite degradation and hence prevent their entry into groundwater table is also an objective of this study.

Microbes are cultured and acclimatized in the lab environment to degrade the pollutants of concern up-to a desired concentration and this culture is used to degrade the leachate samples from landfills to evaluate its efficiency and hence use these microorganisms for onsite bioaugmentation.
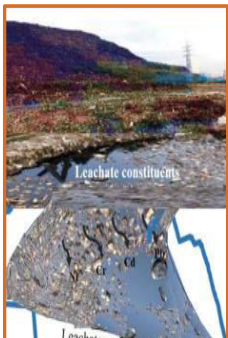
Introduction

In India each day a single person is generating **0.5 kilograms** of waste. A massive pile of garbage is **landfilled** in an unsanitary manner
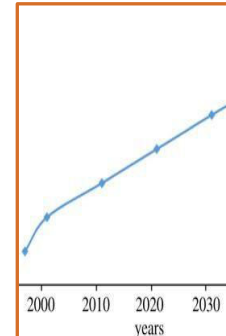
As of Nov 2017, the waste generation was around 53 Million MT per year and **145626 tons/day in India**. The country is expected to produce107.01 Million MT by 2031.

The **waste forms leachate** which percolates deep into the lithosphere and **contaminates the groundwater table.**

Many cities in India like, Ghaziabad, Panipat, Vatva, have reported groundwater **contamination in past due** to **leaching of heavy metals** like Fe, Cu, Ni, As, Pb and Hg

Perfluorooctanoic acid (PFOA)

The emerging contaminant of our concern is perfluorooctanoic acid (PFOA).

It is considered to a surfactant or fluorosurfactant. ant due to its chemical structure.

PFOA is one of many synthetic organofluorine compounds collectively known as per- and polyfluoroalkyl substances (PFASs).

it's a man-made chemical found in products that resist sticking, heat, water, stains, and grease. The most famous brand name for products with resistant qualities is Teflon.

The permissible limit of PFOA in countries like USA, Canada and Germany is 10 PPT, 0.2 PPB, 2-5 PPB respectively.

They can also get into the air, water, and soil as byproducts of the manufacturing process and high levels of exposure may cause:

- Testicular and kidney cancer
- Liver damage
- Thyroid disease
- Ulcerative colitis
- Changes to cholesterol
- Changes in blood pressure during pregnancy.

Study Area

The city in focus is Jammu with GPS coordinates of 740° 24' and 750° 18' East longitude and 320° 50' and 330° 30' North latitude.
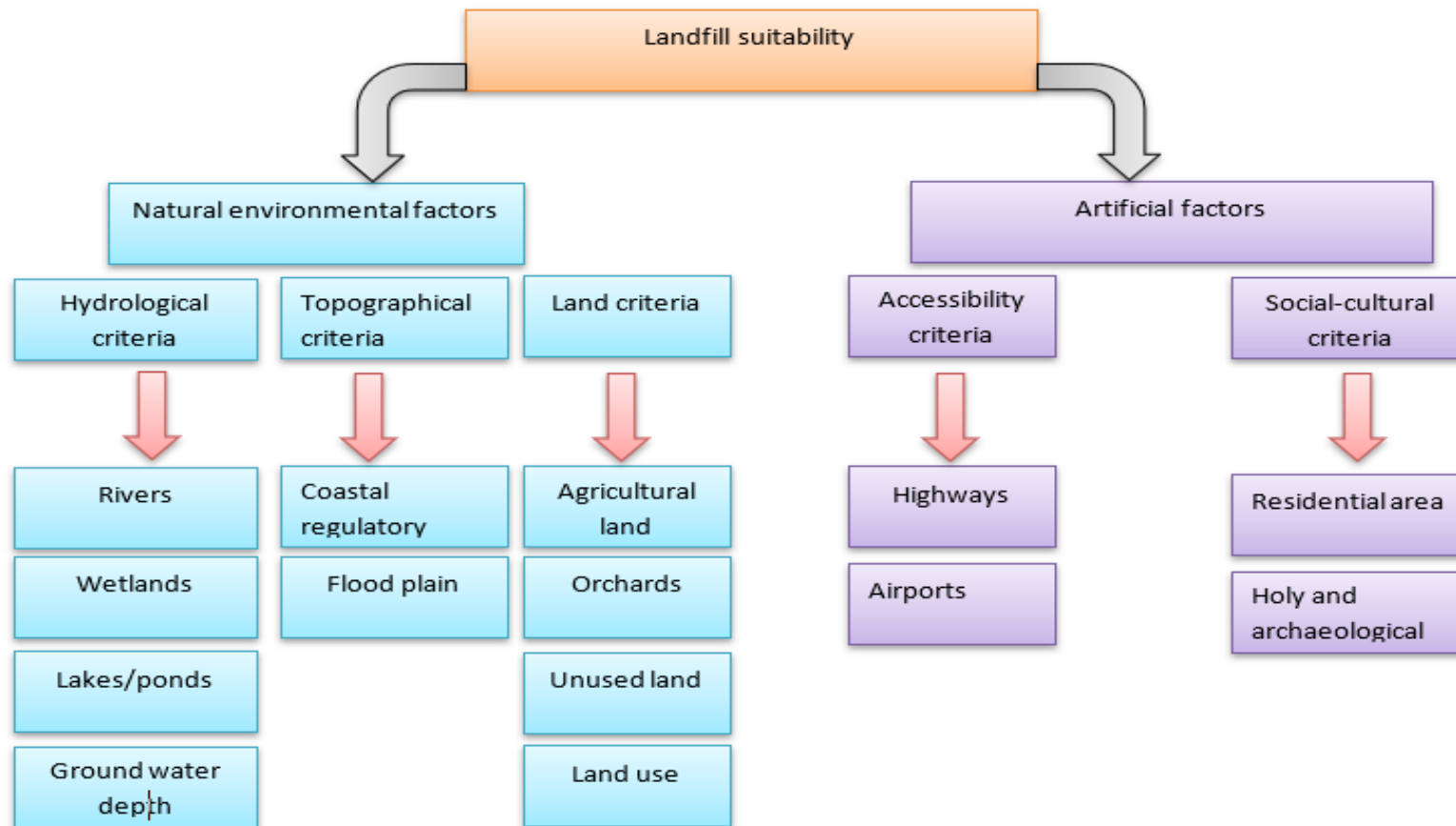
This city is divided into three divisions, 71 wards, and 126 development zones under the 1994 master plan

Jammu's urban area is expected to grow by roughly 287.92 km² by 2021.

The population of Jammu city is 6,64,911 number of people
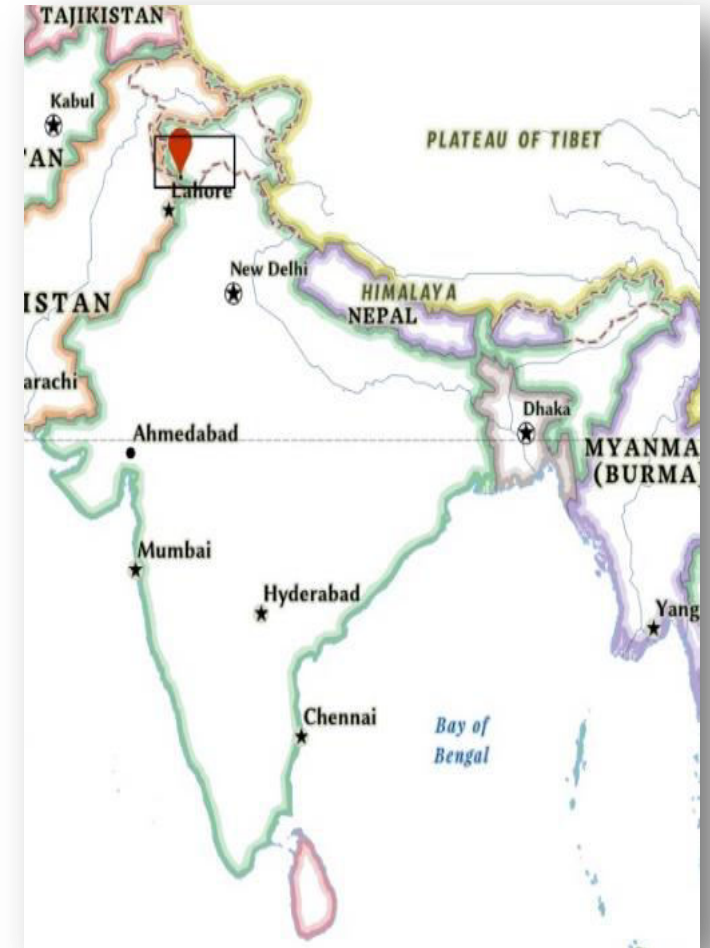
Site selection

Landfill Site Characteristics

Total size of the property	19.5 Acres
Whether hilly terrain or gentle terrain	Hilly Terrain
Ground water depth	≥26 m
Land Use	The site is unused land
Primary crops in the study region	Wheat, maize, and rice
Nearest highway	NH-1A:9.6 km SE
Nearest railway station	Jammu Tawi railway station-16.6 km, SE
Nearest airport	Jammu-(18.8 km) via NH 144A
Water bodies	Chenab river-8.2 km, SE
Reserve forests and ecologically sensitive zone within 10km	Ramnagar (Manda) wildlife sanctuary-4.8 km, SE
Monuments within 10 km	Nil
Major important industries within 10 km	Nil
Residential area	> 4 km

Area details	7.5 acres
Whether undulating terrain or gentle plain	Undulating terrain
Elevation variation	325-350 MSL
Land use	The site is unused land
Distance from river	Tawi river-6.2 km
Nearest town or city	Jammu-4 km
Nearest airport	Jammu-7.4 km
Religious and archaeological site	Raghu nath temple-5.3 km
Nearest Railway station	Jammu Tawi railway station-6.1 km
Nearest Highway	NH-44(9.5 km)
Ecologically sensitivity zone (within 10 km)	Ramnagar (Manda) wildlife sanctuary-5.1 km
Ground water depth	> 15 m

Kot Bhalwal Site

Bhagwati NagarSite

Normalized Pair wise Comparison Matrix

Criteria	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	EIGEN VECTOR
Ground water depth (X1)	0.18	0.13	0.22	0.23	0.17	0.14	0.25	0.14	0.23	0.18	0.20	0.19
Land use (X2)	0.03	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Airports (X3)	0.04	0.09	0.04	0.05	0.10	0.05	0.04	0.05	0.04	0.06	0.03	0.05
Highway (X4)	0.04	0.09	0.04	0.05	0.10	0.05	0.04	0.05	0.06	0.12	0.02	0.06
Holy and Archaeological (X5)	0.04	0.07	0.01	0.01	0.03	0.05	0.04	0.05	0.04	0.03	0.02	0.04
Distance from lake (X6)	0.18	0.13	0.13	0.14	0.10	0.14	0.12	0.14	0.11	0.12	0.13	0.13
Distance from flood (X7)	0.09	0.13	0.13	0.14	0.10	0.14	0.12	0.14	0.11	0.12	0.13	0.12
Distance from river (X8)	0.18	0.13	0.13	0.14	0.10	0.14	0.12	0.14	0.11	0.12	0.22	0.14
Distance from wetlands (X9)	0.09	0.09	0.13	0.09	0.10	0.14	0.12	0.14	0.11	0.12	0.07	0.11
Coastal Regulating zone(X10)	0.06	0.06	0.04	0.02	0.07	0.07	0.06	0.07	0.06	0.06	0.07	0.06
Residential area (X11)	0.06	0.06	0.09	0.14	0.10	0.07	0.06	0.04	0.11	0.06	0.07	0.08

Landfill Site Suitability Index

Local Priorities for the Sites

Alternatives	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Site 1	1	1	1	1	1	1	1	1	1	1	1
Site 2	0.5	1	0.5	1	0.5	1	1	0.5	0.5	1	0.5

Site 1	>26 m	unused land	>18 km	>9 km	nil	nil	Nil	>8 km	>10km	nil	nil
site 2	>15 m	unused land	>7 km	>9 km	>5 km	nil	Nil	>6 km	>5 km	nil	>4km

Global Priorities for the Sites (Final Synthesis)

FINAL SYNTHESIS	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	OVERALL WEIGHT
WEIGHTS	0.188	0.018	0.053	0.060	0.036	0.133	0.124	0.141	0.111	0.058	0.078	
Site 1	1	1	1	1	1	1	1	1	1	1	1	1.00
Site 2	0.5	1	0.5	1	0.5	1	1	0.5	0.5	1	0.5	0.70

Initial Characteristics of Sample

The sample is collected from a natural pond near Kot Bhalwal site and the average initial characteristics were found (In PPM) as:

Ammonia	Nitrtate	BOD	COD	Total Surfactants	Total Phenols	Iron	Manganese
94	67	380	1220	38	35	6.7	5.4

Wastewater was collected and algae was allowed to grow and later transferred to flasks for acclimatization.

The best performing cultures were transferred to 7 L sized reactors and filled with water till 4 L.

R1 was filled with Kaldness media and connected to an aerator at 1-2 LPM aeration.

R2 was equipped with overhead stirrer at 250 RPM

Ammonia, Nitrate and COD removal rates were studied at the batch level studies on alternate days for 2 months.

Wastewater was collected from the campus and subjected to sunlight to allow the algae to grow and later transferred to flasks for further acclimatization.
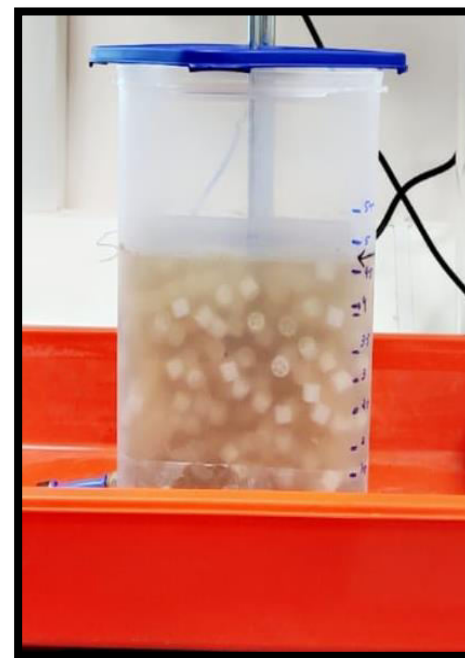
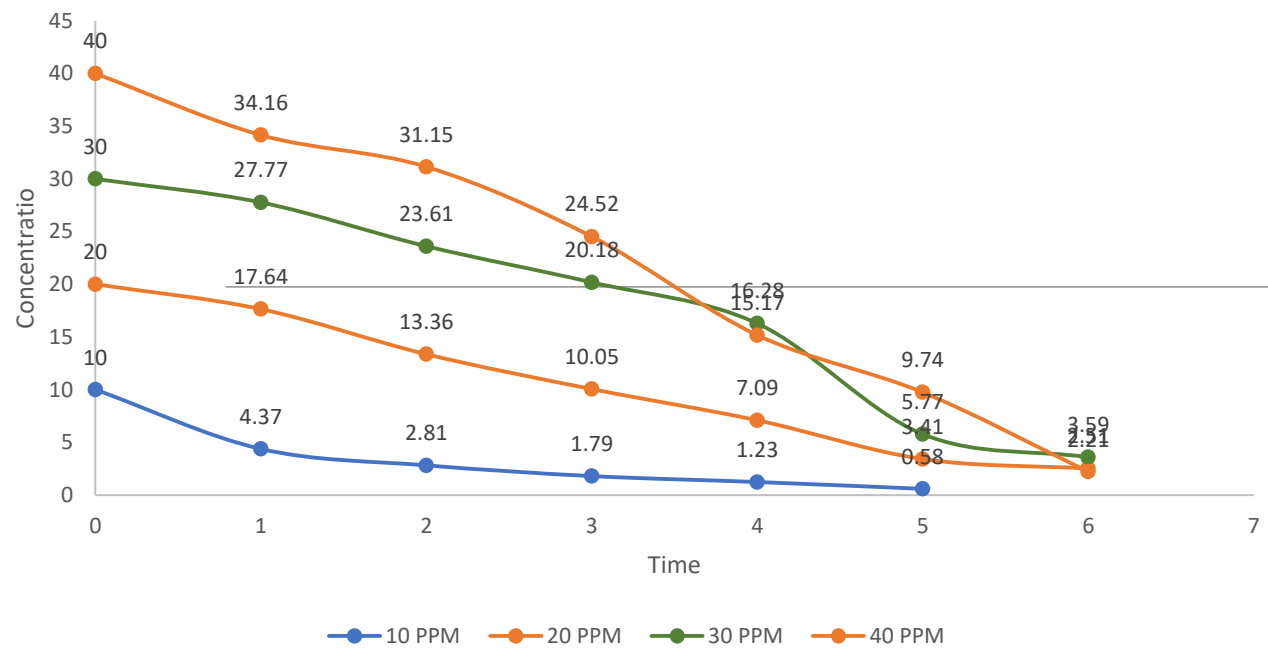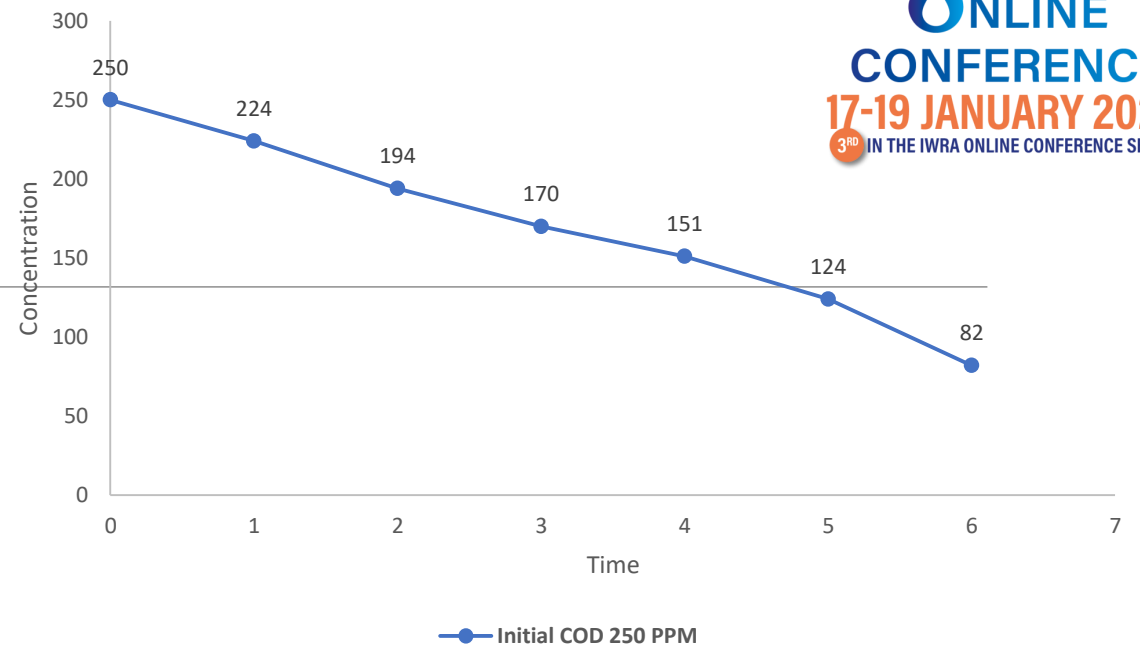R1 contained a PVDF HF membrane and R2 is kept anoxic and no membrane or carriers.

The target parameters are regularly tested and analysed to determine the efficiency of the process and pH was maintained between 8.2-8.6
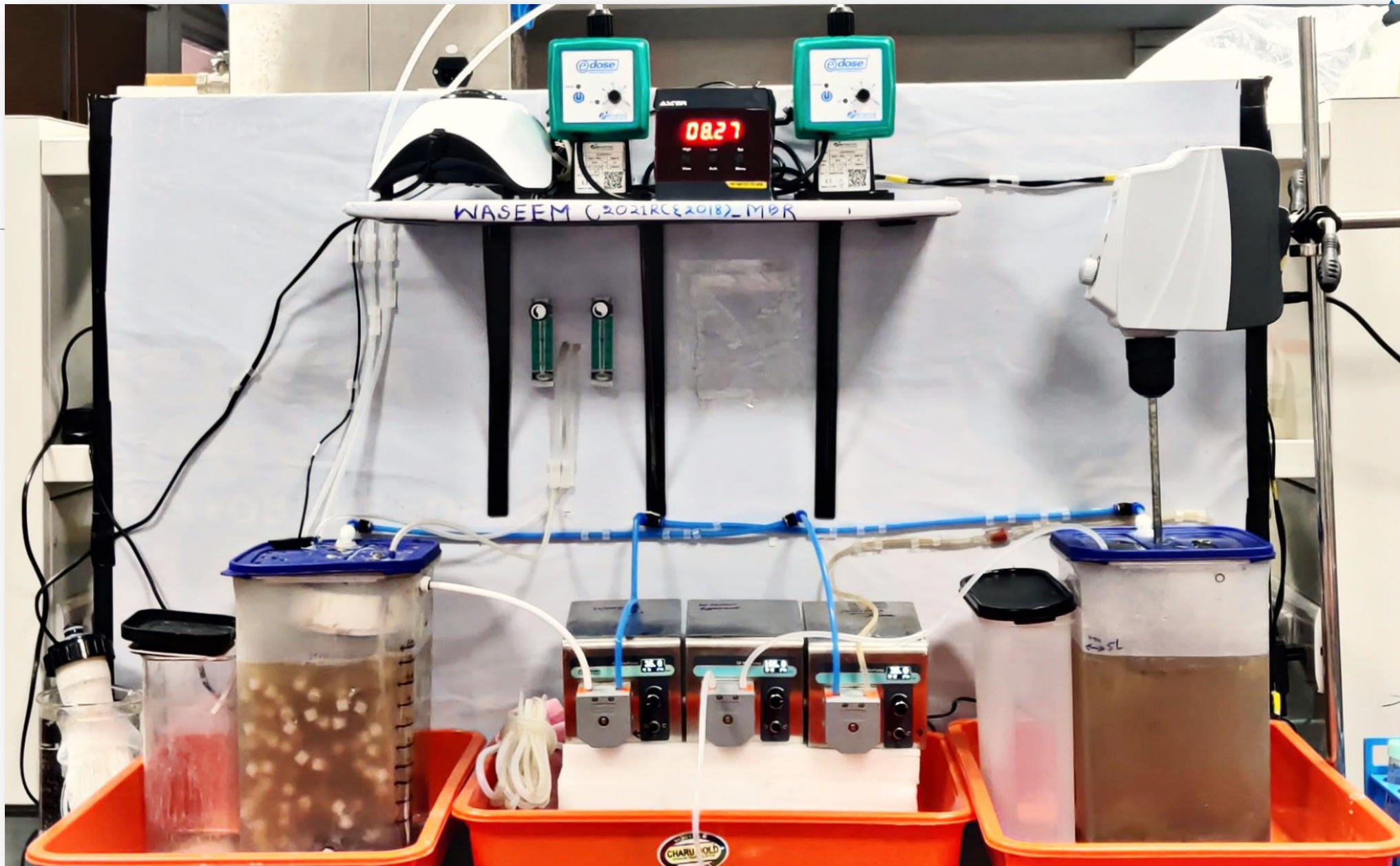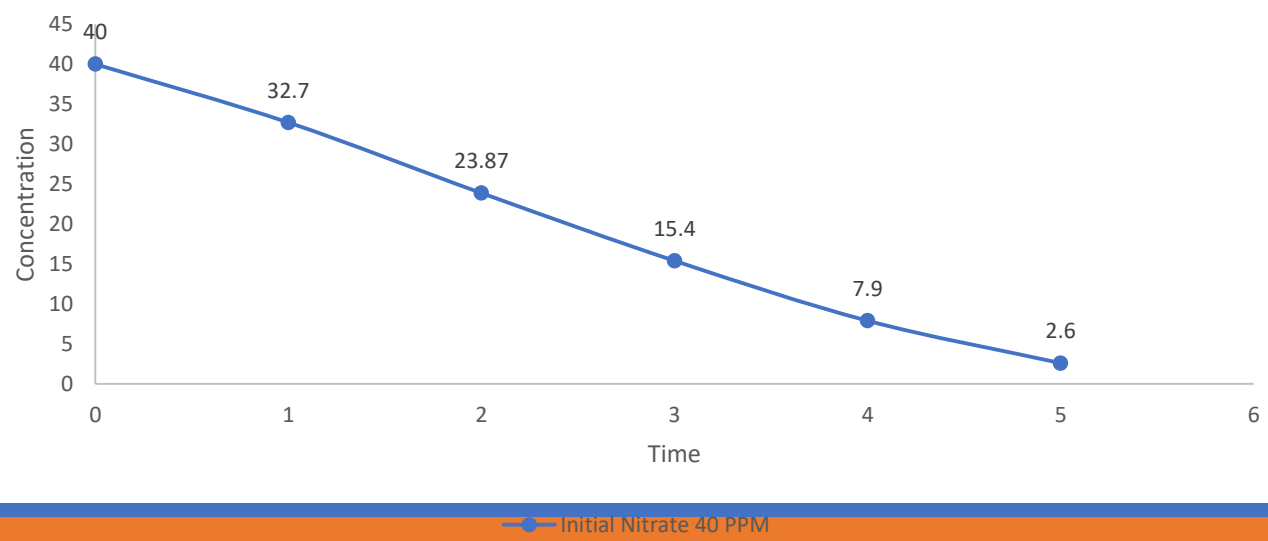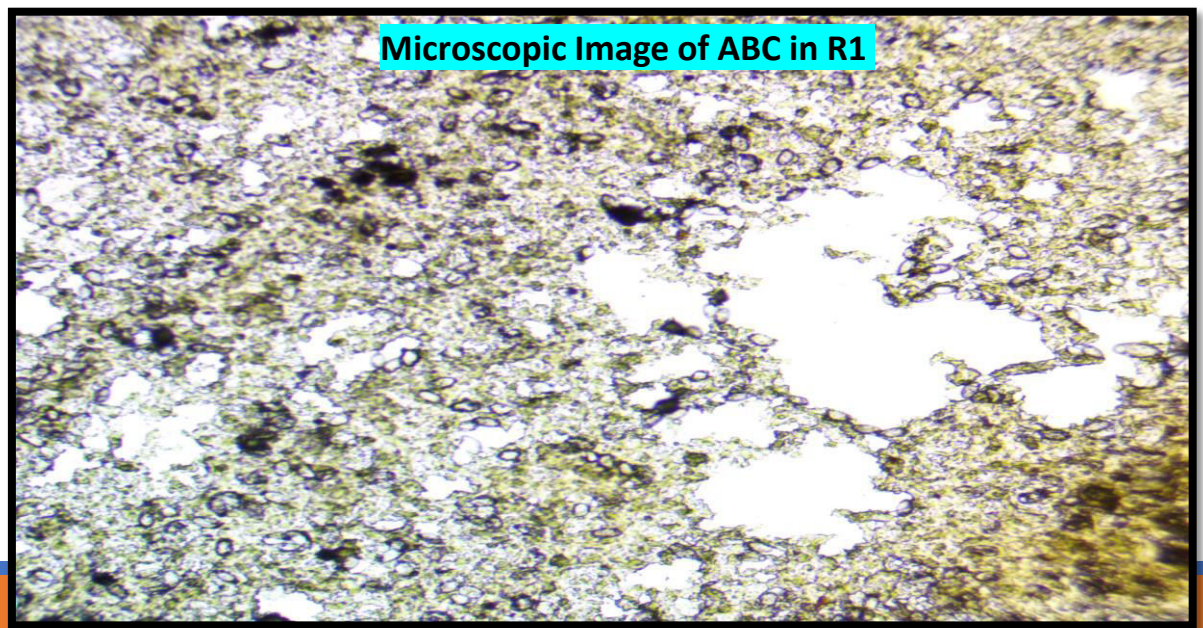
Ammonia Degradation Kinetics in R1

COD Degradation Kinetics in R1

Nitrate Removal Kinetics in R2

Microscopic Image of ABC in R1

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Results

The setup is run at 6 hours HRT and 1 LPM aeration in R1 and the following results are obtained in an average cycle.

Ammonia	Nitrtate	BOD	COD	Total Surfactants	Total Phenols	Iron	Manganese
1.04	0.3	12	54.80	1.89	2.45	1.97	0.87

The above results indicate a removal efficiency of > 90% in Ammonia, nitrate, BOD, COD, surfactants and phenol. Removal efficiency of around 70% was observed for Fe and Mn.
We have started acclimatizing the culture to remove PFOA and other emerging contaminants and the process is still on. The results will be analysed with the help of HRMS and removal efficiency, kinetics and behaviour will be reported later.

THANK YOU