Experiment on a novel approach toward quantifying the toxicity level of the soil around the Yamuna River and checking the impact of polluted water on the soil

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Abstract:

Yamuna water is reportedly consumed by 57 million people every day. The Yamuna River in Delhi receives about 3296 MLD (million litres per day) of sewage per day, and there are about 3.5 lakh jhuggis on the Yamuna riverbed, which adds to the capital's river being one of the most polluted rivers in the nation. The Yamuna river contains a significant amount of heavy metals, and Delhi is extremely polluted in terms of their concentration. Various diseases are caused by dangerously high levels of heavy metals in river water, including cobalt, nickel, zinc, cadmium, and chromium. Yamuna water is also used for irrigation, thereby contaminating the land and the crops that are farmed there. Yamuna water has increased the toxicity of the soil of the bank area.

This experiment aims to quantify the toxic effect of the Yamuna river on the bank area in the Mayur Vihar region of Delhi, India. Under this experiment, the soil samples were collected at various locations from the bank of the river i.e. at the river bank, 100M, 200M, 300M, 500M and 1KM. A square shaped piece of cotton was kept in the middle of these soil samples. The level of decomposition of cotton was closely observed after 1 week, 2 weeks and 4 weeks. The microscopic pictures of the decomposed cotton pieces were also examined to quantify the microbial activity in these soil samples. The image processing and a convolutional neural network machine learning model was applied to calculate the level of decomposition and the fertility coefficient in order to identify the impact of yamuna water on the soil. In parallel, the above soil samples were tested in a chemical laboratory to validate the results of experiments. It was concluded that the decomposition has a direct connection with the carbon content and heavy metals present in the soil. While the soil sample collected near the river bank had the lowest carbon content, it also exhibited the lowest decomposition of the cotton and thereby directly indicated the lower microbial activity.

Another experiment was conducted on the above soil samples by sowing holy basil seeds in them and carefully observing the growth of basil seedlings in these soil samples. The pattern of growth of these holy basil plants indicates that the level of soil fertility (that is represented by soil organic carbon) increases steadily from the river bank to a certain distance away from the river, and then it stabilizes.

Keywords: Soil Testing, Soil Toxicity, Cotton Assay Test, Microscopic analysis

1. Introduction:

It's undeniable that water is one of the most essential resources for sustaining life. Its versatility and importance in our life is incomparable. Most human activities, whether domestic, agricultural or industrial have an impact on water and the ecosystems. Water pollution, a major global environmental issue, has also assumed a serious threat to sustainable development in India. World Health Organization (WHO) statistics indicate that half of India's morbidity is water-related. About

70% of India's surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic, organic and inorganic pollutants due to mismanaged disposal of industrial effluents, domestic wastes and agricultural pollutants. In many cases, these water sources have been rendered unsafe for human consumption as well as for other activities such as irrigation and industrial needs. Water p-ollution consequently contributes to soil pollution and vice versa. Humans have relied on soil as a source of riches for an indefinite amount of time, and they still do now. Water and soil contamination represent a serious threat to humankind since they can cause acute toxicity, mutagenesis, carcinogenesis, and teratogenesis for humans and other organisms.

Soil is considered a living system due to its biological components - fungi, bacteria and plant roots. Soils are classified on the basis of their dominant chemical and physical properties that include extent and nature of soil formation, climate, topography, base saturation, clay mineralogy, and amount of organic matter. While physical properties maintain the soil's structural framework, the biological components govern the biogeochemical changes in the soil. To prevent soil from gradually degrading, often, both mineral and organic additions have been used. The stability, fertility, and biogeochemical cycles are all significantly influenced by biological activity, particularly microbial activity.

1.1. Effects of potentially toxic elements on soil microbial activity:

Common and significant recalcitrant pollutants, such as potentially poisonous substances, have an impact on the variety, abundance, and microbial activity of soil microorganisms. Microbes are important for soil fertility and primary production because they play a significant role in nutrient cycling and the breakdown of organic materials in the soil. Bacteria and fungi make up the majority of the soil microbial biomass, which is valuable for researching the detrimental impacts of toxic metals at the cellular level. The quantity of metal bioaccumulation by absorption, migration, and transformation determines the hazardous effect of potentially dangerous elements. The inactivation of enzyme activity centres, electron-donating groups like mercapto protein, nucleic acid base and phosphate combination, accumulation of toxic metals more than the capacity of organisms to bear, resulting in biological disease and death; inhibition in the formation of metallothionein or metalloprotein are just a few of the negative effects of higher concentrations of toxic metals on microorganisms. Numerous studies have demonstrated that cells with higher levels of metallothionein elicit anti-apoptotic effects, while cells with lower levels of metallothionein are more susceptible to apoptotic cell death.

The primary contributor to all soil biochemical reactions are soil microorganisms. The tools for preserving soil quality, creating soil organic matter, destroying dangerous compounds, creating soil structure, and establishing bio-chemical cycles are soil biochemical processes. Toxic metal contamination of soils reduces soil microbial characteristics such as soil respiration and enzymatic activity. The pH level, organic content, and other chemical characteristics of the soil, all affect its microbial composition. Extreme pollution with potentially hazardous elements limits soil microbial activity and poses a major threat to the health of the soil ecosystem.

1.2. Effects of potentially toxic elements on soil microbial composition:

Potentially harmful substances initially affect the kind and quantity of the soil's microbial population, including its bacteria, fungi, actinomycetes, and other organisms. Potentially harmful element pollution in soil alters its chemical and biological composition as well as the microbial community patterns. Those soil microorganisms that can be specially adapted exist in soils that have been contaminated by potentially harmful substances over a long period. The amount of organic carbon in the soil, a measure of the impact of potential toxic element pollution, is inversely associated with the effectiveness of microbial communities in organic mineralization, because they aid in nutrient cycle, plant symbiosis, and the detoxification of toxic substances and microbial populations in soils that are crucial (used to control plant pests and plant growth). Microbial biomass causes a loss in functional diversity and changes in microbial community structure when metal-enriched sewage sludge is introduced to soils. However, exposure to metal can also result in the growth of a population of bacteria that are tolerant to it.

1.3. Impact of potentially toxic elements on humans:

An important route for potentially harmful substances to enter the food chains of humans and animals is through the uptake of these substances by plants from polluted soils. The inhalation and ingestion are the two major ways by which potentially toxic components that bioaccumulate in the food chain and are detrimental to humans enter the body. In addition to that, humans have long employed the potentially poisonous elements to create metal alloys and pigments for paints, cement, paper, rubber, and other materials. When these plants are directly or indirectly consumed, these potentially hazardous components enter the body system and may bioaccumulate over time. Potentially harmful substances that enter the body through any route have an impact on the immune system, fundamental physiological functions of cell and gene expression, and may cause nausea, anorexia, vomiting, gastrointestinal abnormalities, and dermatitis. Due to the extended half-life of Cadmium (Cd) and enhanced food absorption, women are more susceptible to the negative effects of Cd and have higher body burdens. Low-level cumulative exposure to Cd has also been linked to abnormalities in renal function and bone metabolism. Potentially harmful substances, primarily lead (Pb), affect and harm body systems and organs such as the kidney, liver, and modify the blood's composition in addition to harming the lungs, reproductive system, central nervous system, urinary system, and immune system. According to Chen, employees who have frequent contact with nickel powder are more prone to develop nasopharyngeal cancer and respiratory cancer. Copper co-factors for several redox cycling enzymes when present in lower concentrations; but at larger levels, copper disturbs human metabolism and causes anaemia, liver and kidney damage, stomach and intestinal discomfort, and other health problems. Arsenic (As) causes malignancies of the skin, liver, lung, colon, and uterus.

1.4. Impact of potentially toxic elements on plant growth:

Plants can absorb potentially harmful substances that are water-soluble or that are easily absorbed by roots from soil. Because potentially harmful substances cannot be broken down, when their concentrations within a plant exceed the allowable limit, they have a negative direct and indirect impact on the plant. Direct harmful consequences of potentially toxic elements on plants include leaf chlorosis, water imbalance, reduced stomatal opening, suppression of cytoplasmic enzymes, and cell structural destruction as a result of oxidative stress. One example of an indirect harmful effect is when potentially hazardous substances replace necessary nutrients at cation exchange sites in plants.

2. Impact of polluted Yamuna water on the agricultural practices:

The Yamuna River starts in Yamunotri in Uttarakhand and travels roughly 1380 kilometres through the states of Himachal Pradesh, Uttar Pradesh, Uttarakhand, Haryana, and Delhi. It is a sacred river, and people consume its water for a variety of uses, including bathing, agriculture, and residential water supply. Yamuna water is reportedly consumed by 57 million people every day. The Yamuna River in Delhi receives about 3296 MLD (million litres per day) of sewage per day, and there are about 3.5 lakh jhuggis (slums) on the Yamuna riverbed, which adds to the capital's river being one of the most polluted rivers in the nation. Most of the pollution in the Yamuna is thought to originate during its journey. The Yamuna river contains a significant amount of heavy metals, and Delhi is extremely polluted in terms of their concentration. Various diseases are caused by dangerously high levels of metals in river water, including cobalt, nickel, zinc, cadmium, and chromium (Kumar,2010). Agriculture is also impacted by Yamuna pollution, in addition to human health. Yamuna water is used for irrigation, contaminating the land and the crops that are farmed there. The TERI (2014) paper states that common crops including brinjal, cauliflower, radish, tomato, and cabbage have significant levels of chemicals and pathogens of various kinds. Water is continuously inhaled as a result of urbanisation, which causes the water table to drop. The livelihood of people is threatened by the disposal of solid and liquid waste and by encroachment on river waterways, both of which contribute to the deterioration of water quality. Groundwater pollution has impacted the state of the economy by altering farming practices, lowering agricultural yields, and shortening the lifespan of irrigation systems.

The Municipal Corporation of Delhi (MCD) determined that 15% of Delhi's water was unfit for human consumption in 2009. With 50% of the water samples being classified as dirty, South Delhi was found to have the highest contamination levels. Untreated home wastewater, agricultural runoff, untreated industrial effluents, and trash from religion are the biggest contributors to water pollution in the Yamuna river. According to Table 4, 80% of the respondents in the Mayur Vihar region claimed that the Yamuna water's condition is poor, while the remaining 20% said that it is very poor.

According to a 2003 study by Mohammad and Muzareh, the application of polluted water affects the soil's chemical composition and fertility. Continuous application may cause heavy metal and plant nutrient accumulation in the soil, which could cause a nutrient imbalance, leaching, and salt buildup. If this is not adequately handled, it will lower soil fertility and productivity.

The amount of wastewater produced rises as industrialization and urbanisation progress, and this wastewater is discharged into the river. Agricultural fields are irrigated with polluted water, which over time has an impact on crop productivity levels.

Table 1: Mayur Vihar

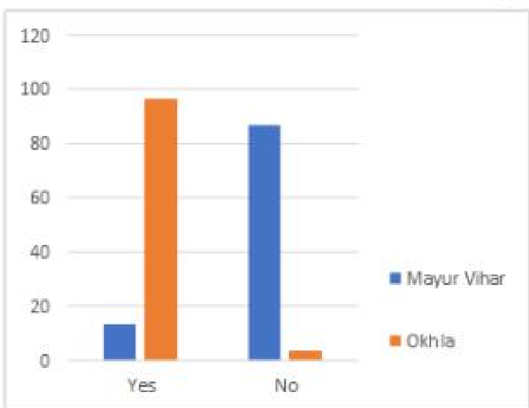
The Decrease in crop production	Percentage(%)
Yes	10
No	90

Table 2: Okhla

The Decrease in crop production	Percentage(%)
Yes	100
No	0

According to a 2012 India Today article titled *"Vegetables washed in highly-polluted Yamuna water could kill you"*, the majority of the veggies arriving at Delhi's wholesale vegetable & fruit markets are washed in highly poisonous Yamuna water to give the food a shine. All (100%) of the responders from Mayur Vihar and Okhla said that they used wax and oils to make the vegetables shiny. Despite an increase in demand, vegetable prices also rise.According to the results of the current investigation, none of the respondents believed that Yamuna water was to blame for the shine on the veggies. Graph 6 shows the respondents' distribution depending on their opinions on how the Yamuna water affects the flavour of crops (N=60, 30 respondents each from the Mayur Vihar area and Okhla). The excessive buildup of heavy metals in agricultural soils due to wastewater irrigation may not only contaminate the soil but also cause crops to absorb more heavy metals, affecting the quality and safety of food. Long-term wastewater irrigation in the research areas has contaminated the soils and food crops, which has a negative impact on the quality of the vegetables and harvests, it was discovered in 2009.

Distribution of the respondents based on the perception of the effects of Yamuna water on the taste of crops:

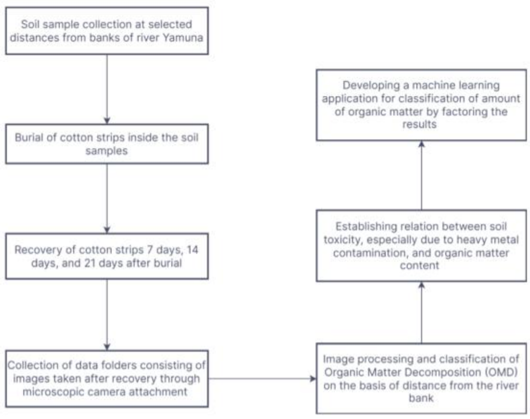


2.1. Concept

In this paper we will be discussing an explication of the effect Yamuna river's contamination has had on the soil lying at/nearby its banks and associated agricultural practices by utilizing image processing and machine learning for soil phenotyping and analysing important soil features such as Organic matter decomposition (OMD) and contamination levels.

This project presents a protocol for measuring soil organic-matter (SOM), extent of soil contamination and how it affects microbial activity within the soil. Organic matter decomposition (OMD) within soil has been quantified/represented by the breakdown of cellulose in the form of woven cotton strip/fabric buried inside soil, inspired by the Cotton strip assay test, which is a technique for estimating soil microbial activities by measuring the loss in the cotton strip's tensile strength.

We have redesigned this existing technique/protocol and excluded the strength measurement and formulated a new protocol to understand how different colours(microbial pigments), their sizes, patterns and abundances on the surface of the strip relate to organic matter decomposition and how it ultimately gives an insight into its relation with soil contamination.



3. Methodology

There are many steps that we followed

- Sample Collection
- Setting up the experiment
- Setting up the cotton pieces
- Setting cotton assay test
- Weekly observations
- Lab testing
- Sapling Plantation
- Sapling height observation
- Image processing of the cotton piece to check decomposition
- Machine Learning

3.1. Sample Collection

This marked the first step toward the project execution. As we have planned to keep the research to the Yamuna river area . I have visited the Yamuna river bank near mayur vihar and collected soil samples from the following distances from the river:

1. At the shore
2. 100 metre away from the river
3. 200 metre away from the river
4. 300 metre away from the river
5. 500 metre away from the river
6. 1 Km away from the river

3.2. Setting up the experiment

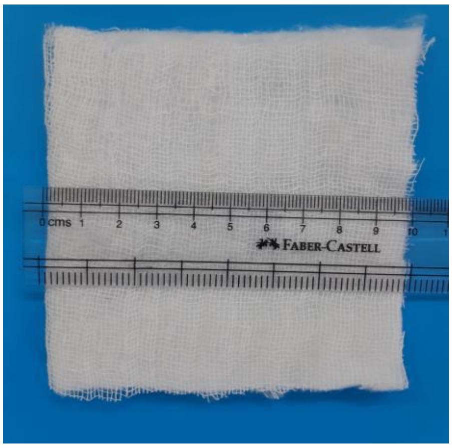
After collecting the samples of the soil we planned to begin with the experiment by testing the soil. We researched various soil testing experiments, finding numerous tests utilizing multiple reagents and sophisticated instruments to determine the soil fertility and estimating soil microbial activities. However, we were looking for a soil analysis method that would use equipment which is readily available, require negligible chemical involvement, and can detect gross trends in organic matter and contamination in a soil monitoring program.

Therefore,we planned to go with the cotton strip assay (CSA) test. Cotton strip assay is not a new technique for estimating soil microbial activities, but researchers mostly measured the loss in the cotton strip's tensile strength which requires an expensive and sophisticated instrument. We have redesigned this existing technique/protocol and excluded the strength measurement and formulated a new protocol to understand how different colours(microbial pigments), their sizes, patterns and abundances on the surface of the strip relate to organic matter decomposition and how it ultimately gives an insight into its relation with soil contamination.

The CSA method using image analysis is one of the most affordable techniques to measure soil microbial activity. CSA using image analysis can be a valuable tool in conjunction with other simple indicators of soil physical and chemical health such as slaking and pH for soil analysis.

3.3. Setting up cotton pieces

So after planning to go with the soil assay test we took a box with 6 containers and we set up the soil samples in them and then we arranged cotton pieces in a thin cloth. All the pieces are of 10cm in size



3.4. Setting cotton assay test

After setting up the soil in the container we took cotton pieces, rolled them into very thin cloth and then buried it in the middle of the soil sample.

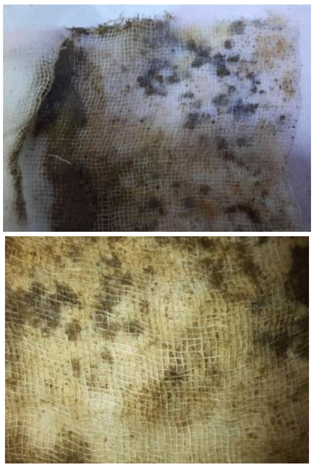
3.5. Weekly Observations

Then we left it there for 1 week and took observations and then after 2 weeks and then after 4 weeks. During the first week we got some visible results but we found that they are not enough to check or quantify the full effect of the decomposition. Then after that we took another observation of the same sample after 2 weeks where we found a clear difference of the decomposition and these effects increased to a really good level after 4 weeks.

Week 1 Week2

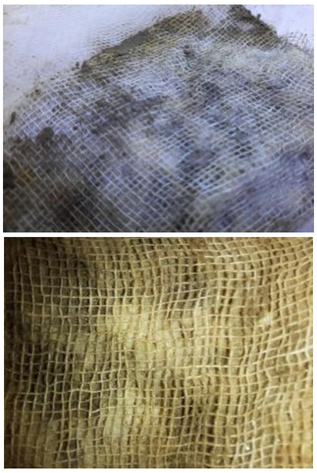
At shore

100m



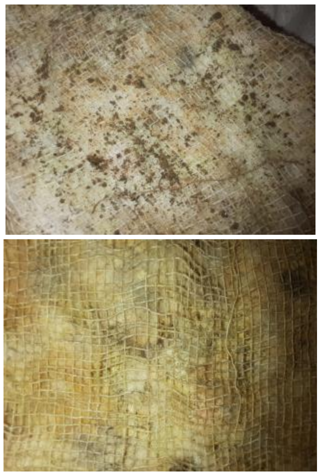
200m

300m



500m

1000m



4. Results

To do the validation of our experiment we have got our soil samples tested from Opal Research and Analytical Services. From the tests we have found that there is a big difference in the carbon content of the soil. For example the carbon content is lowest at the bank of the river whereas it increases with the increase in distance but it decreases after 1Km away from the Yamuna River. There are many other differences also like the npk values were low at the bank and increasing with increase in distance and there is a higher amount of heavy metals mixed in the soil near the bank than the other samples.


ORAS Opal Research & Analytical Services (TM)
Mob.: 9369069069, 9717567863, 9053355335
ISO 9001 : 2015
STQC Directorate Certificate No. CETE/N/4321/2018, Govt. Of India
An ISO 9001 : 2015 Certified Govt. Approved Laboratory

Test Report

Report No : ORAS/CT/00020220410162	Date : 21/07/2022
Issued to :- TANUSH ARORA, Flat No.-21, Anamika Apartments, Plot No.-99, IP Extn., Patparganj, Delhi-110092	Your Reference : Email
	Date of Receipt : 16/07/2022
	Our Reference : Email
	Test Started on : 16/07/2022
	Test Completed on : 21/07/2022
Sample Description : One sample received as "Soil-A-200"	

Chemical Analysis of "Soil"

S. No.	Parameter	Test Result	Requirement	Test Method
1	C:N Ratio	1:6.20	------	LAB SOP
2	Total Organic Carbon	11.29%	------	LAB SOP
3	PH 10% as water solution	7.40	6.50 to 8.50	IS (3025pt-39)
4	Electric Conductivity	670 micro mhos/cm	500 to 2000	IS (3025pt-39)
5	Moisture	19.85%	10 to 20 %	LAB SOP
6	Particle Size	100-670µm	Min.500µm	LAB SOP
7	Bulk Density	2.52	------	LAB SOP
8	Total Nitrogen	1.82%	0.08%	IS:3025
9	Total Phosphate	4.17%	4.5%	LAB SOP
10	Total Potash	2.19%	0.4%	LAB SOP
11	Pathogen	Absent	Absent	IS:1622

Heavy Metals Analysis of "Soil"

S. No.	Parameter	Test Result	Requirement	Test Method
1	Chromium	2.80ppm	15 ppm	AAS
2	Nickel	1.47ppm	----	AAS
3	Copper	6.18ppm	15 ppm	AAS
4	Mercury	Not detected	1.5 ppm	By Spectrophotometer
5	Cadmium	0.10ppm	1.5 ppm	AAS
6	Arsenic	Not detected	1.5 ppm	AAS
7	Lead	1.10ppm	1.5 ppm	AAS
8	Zinc	118ppm	300ppm	AAS
9	Calcium	130ppm	300ppm	AAS
10	Iron	2.48ppm	50ppm	AAS
11	Magnesium	7.45ppm	50ppm	AAS
12	Boron	8.60ppm	50ppm	AAS

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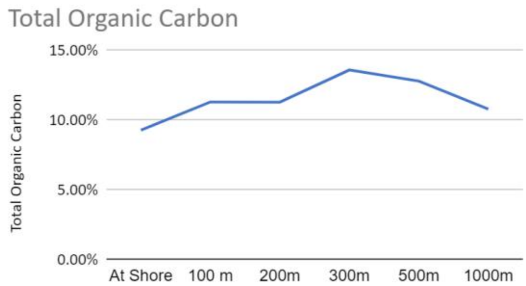
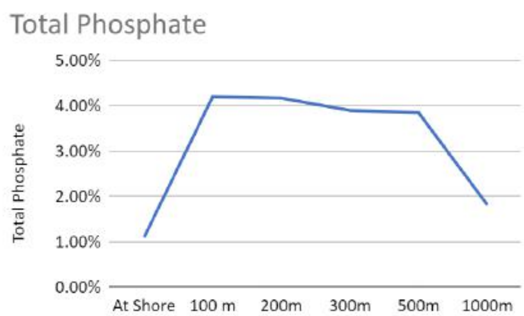
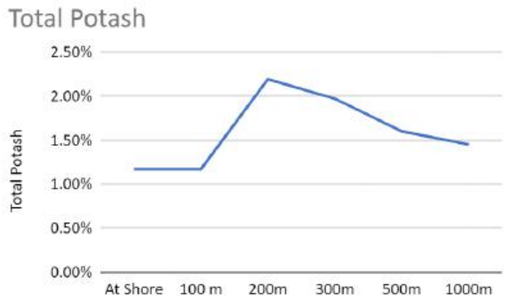
Followings are the graphs showing the change in the values with change in the distance







Chemical Analysis of Soil						
Parameter	At Shore	100 m	200 m	300 m	500 m	1000m
C:N Ratio	1:(8.43)	1:(5.9)	1:(6.2)	1:(9.25)	1:(5.8)	1:(8.3)
Total Organic Carbon	9.28%	11.30%	11.29%	13.60%	12.80%	10.79%
PH 10% as water solution	7.1	7.3	7.4	7.85	7.65	7.29
Electric Conductivity	485	680	670	718	790	590
Moisture	19.85%	20.19%	19.85%	21.39%	18.75%	21.30%
Particle Size	100-600 µm	100-700 µm	100-670 µm	100-650 µm	100-550 µm	100-650 µm
Bulk Density	2.22	2.5	2.52	2.45	2.6	2.49
Total Nitrogen	1.10%	1.90%	1.82%	1.47%	2.15%	1.28%
Total Phosphate	1.10%	4.20%	4.17%	3.90%	3.85%	1.82%
Total Potash	1.17%	1.17%	2.19%	1.97%	1.60%	1.45%
Pathogen	Absent	Absent	Absent	Absent	Absent	Absent

Heavy Metal Analysis of Soil						
Parameter	At Shore	100 m	200 m	300 m	500m	1000m
Chromium	2.45ppm	3.90 ppm	2.80 ppm	3.70ppm	3.15ppm	3.47ppm
Nickel	1.1	1.70	1.47	0.7	1.60p	1.2

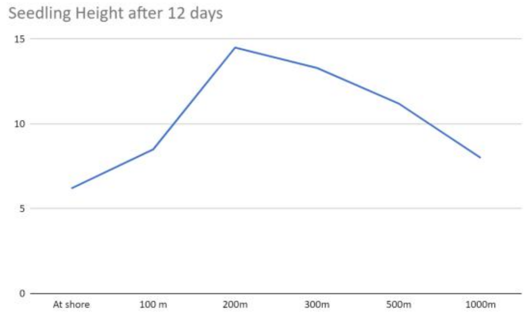
	5ppm	ppm	ppm	0ppm	pm	0ppm
Copper	2.40ppm	6.19 ppm	6.18 ppm	4.19ppm	6.70ppm	2.79ppm
Mercury	0.10ppm	0.15 ppm	-	0.18ppm	0.20ppm	0.12ppm
Cadmium	0.16ppm	0.10 ppm	0.10 ppm	0.12ppm%	0.15ppm	0.18ppm
Arsenic	-	-	-	-	-	-
Lead	-	0.17 ppm	1.10 ppm	0.16ppm	0.20ppm	-
Zinc (ppm)	28	48	118	110	28	42
Calcium	27ppm	70ppm	130 ppm	128 ppm	52ppm	38ppm
Iron	4.5 ppm	4.18 ppm	2.48 ppm	3.75ppm	2.97ppm	5.40ppm
Magnesium	12.25ppm	14.30ppm	7.45 ppm	8.10ppm	12.39 ppm	14.29ppm
Boron	13.19ppm	14.70ppm	8.60 ppm	10.39ppm	15.60 ppm	16.10ppm

4.1. Sapling Plantation :

We sowed a few(4-5) holy basil (Ocimum tenuiflorum) seeds in each soil sample. After the seeds germinated into small saplings, we started watering them on a regular basis. We found drastic differences in the heights of seedlings planted in each sample after a span of merely 12 days.

Sapling Height Observations:

Distance	Seedling Height
At shore	6.2 cm
100 m	8.5 cm
200 m	14.5 cm
300 m	13.3 cm
500 m	11.2 cm
1000 m	8 cm



4.2. **Image Processing:**

As you have seen the cotton sample pictures after one and two weeks of decomposition. So to analyse the decomposition we have used image processing to detect the totally decomposed, partially decomposed area and not decomposed area. Then we have checked their size and accordingly calculated the overall level of decomposition.

4.3. Code:

We have used OpenCV Library to do the image processing and the numpy library to handle the data in the form of arrays. First of all we have used a code to convert our sample videos into JPEG pictures to create a very big data set of the pictures of various soil samples to do a good analysis. After that we did the image processing on all the images by importing them into a python code given below.

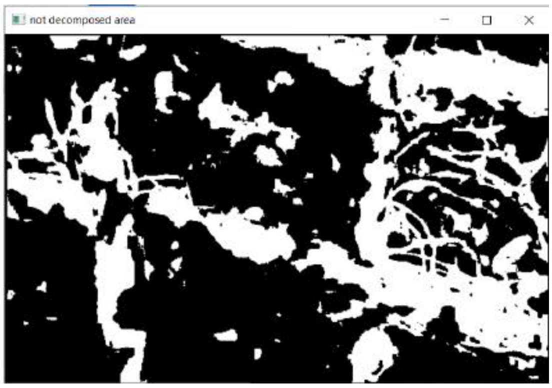
Following is the sample code applied on one image to check the decomposition level of the cotton piece.

```
import numpy as np

import cv2

# Importing the image

img = cv2.imread(r'C:\Users\Admin\Desktop\tanush1.JPG')

hsv = cv2.cvtColor(img,cv2.COLOR_BGR2HSV)
```

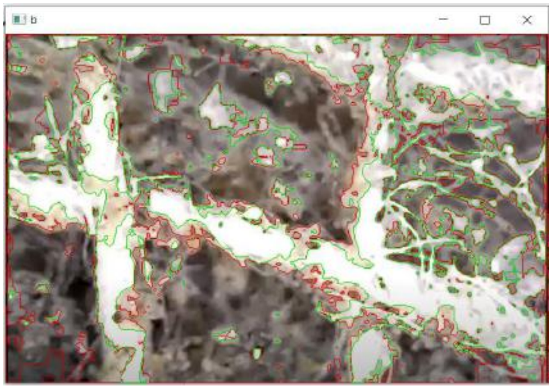
```
# Setting up the color bound and the range

l = np.array([0,0,175])

u = np.array([179,23,255])

l1= np.array([0,14,0])

u1= np.array([179,255,194])


# Generating mask

mask = cv2.inRange(hsv,l,u)

mask2= cv2.inRange(hsv,l1,u1)

# Calculating the total decomposed and not decomposed area

wh = np.count_nonzero(mask)

wh1 = np.count_nonzero(mask2)

# Creating contours around the areas

cont1,har1= cv2.findContours(mask2,cv2.RETR_TREE,cv2.CHAIN_APPROX_SIMPLE)

cont,har= cv2.findContours(mask,cv2.RETR_TREE,cv2.CHAIN_APPROX_SIMPLE)


for i in cont1:

    cv2.drawContours(img,[i],-1,(0,0,200),1)

for i in cont:

    cv2.drawContours(img,[i],-1,(0,200,0),1)

# Displaying images

cv2.imshow('not decomposed area',mask)

cv2.imshow('b',img)

cv2.imshow('Decomposed area',mask2)

cv2.waitKey(0)

cv2.destroyAllWindows()


# Calculating the total percentage of decomposition
```

```
print(wh,wh1)

dimensions = (img.shape[0]*img.shape[1])

print(dimensions)

print("not decomposed area:",(wh/dimensions)*100)

print("Decomposed area:",(wh1/dimensions)*100)
```

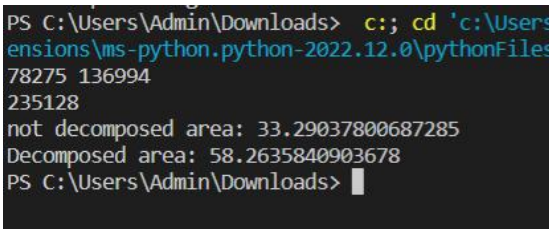
4.4. Results from Image Processing



Contouring:

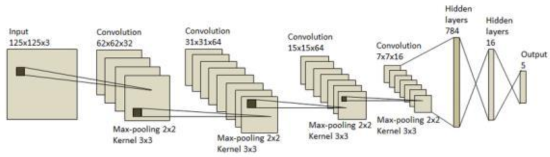


Percentage Calculation:



4.5. Machine Learning

After image processing we have used the same images to implement machine learning to find the toxicity and fertility coefficient of the soil sample. We have used convolutional neural networks to implement the image classification model. As we have checked the quality of our soil samples by doing the lab testing and also by checking the planted sapling growth. We have used the TensorFlow model algorithm to train the model.



Following is the code to train the model:

Importing the library:

```
from tensorflow.keras.models import Sequential

from tensorflow.keras.layers import Conv2D

from tensorflow.keras.layers import MaxPooling2D

from tensorflow.keras.layers import Activation

from tensorflow.keras.layers import Flatten

from tensorflow.keras.layers import Dense

from tensorflow.keras import backend as K

from tensorflow.keras.preprocessing.image import ImageDataGenerator

from tensorflow.keras.optimizers import Adam

from tensorflow.keras.preprocessing.image import img_to_array

from tensorflow.keras.utils import to_categorical
```

```
from sklearn.model_selection import train_test_split


from imutils import paths
import matplotlib.pyplot as plt
import numpy as np
import argparse
import random
import cv2
import os
import warnings
from tqdm import tqdm_notebook as tqdm
import itertools


import tensorflow as tf
print(tf.__version__)
warnings.filterwarnings("ignore")
SEED = 42  # set random seed
```

Setting up the CNN :

```
class LeNet:
  @staticmethod
  def build(width, height, depth, classes):
    # initialize the model
    model = Sequential()
    inputShape = (height, width, depth)


    # if we are using "channels first", update the input shape
    if K.image_data_format() == "channels_first":
      inputShape = (depth, height, width)

    # first set of CONV => RELU => POOL layers
    model.add(Conv2D(20, (5, 5), padding="same",input_shape=inputShape))
    model.add(Activation("relu"))
    model.add(MaxPooling2D(pool_size=(2, 2), strides=(2, 2)))


    # second set of CONV => RELU => POOL layers
    model.add(Conv2D(50, (5, 5), padding="same"))
    model.add(Activation("relu"))
    model.add(MaxPooling2D(pool_size=(2, 2), strides=(2, 2)))


    # first (and only) set of FC => RELU layers
    model.add(Flatten())
    model.add(Dense(500))
    model.add(Activation("relu"))


    # softmax classifier
    model.add(Dense(classes))
    model.add(Activation("softmax"))


    # return the constructed network architecture
    return model
```

Setting up the train and test data:

```
(trainX, testX, trainY, testY) = train_test_split(data, labels, test_size=0.25, random_state=42)
```

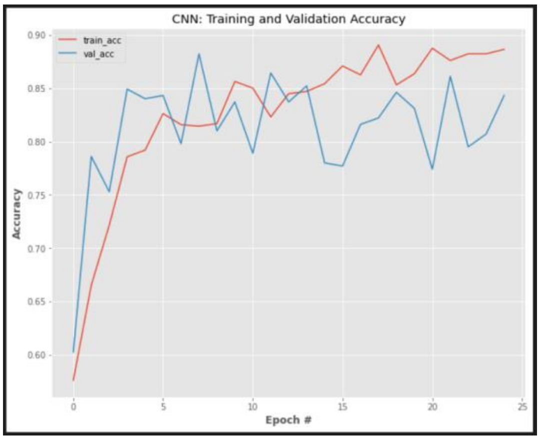
In this code we have used 75% of the total data to train the model and the rest 25% data to test the accuracy of the model.

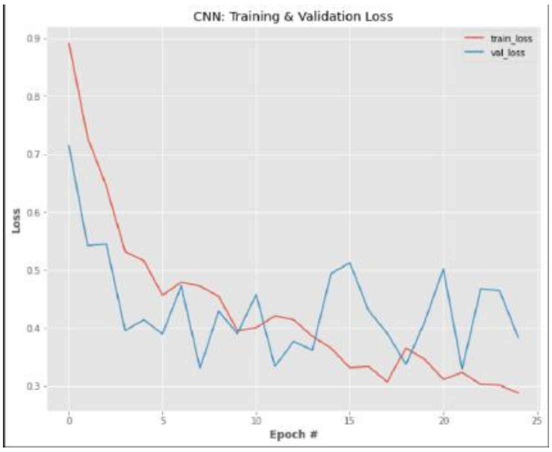
```
# initialize the model

print("[INFO] compiling model...")

model = LeNet.build(width=28, height=28, depth=3, classes=3)

opt = Adam(lr=INIT_LR, decay=INIT_LR / EPOCHS)

model.compile(loss="categorical_crossentropy", optimizer=opt, metrics=["accuracy"])


print("[INFO] model complied...")
```

```
# train the network

print("[INFO] training network...")

H = model.fit(x=aug.flow(trainX, trainY, batch_size=BS),

        validation_data=(testX, testY),

        steps_per_epoch=len(trainX) // BS,

        epochs=EPOCHS,

        verbose=1)
```

Plotting the accuracy of the model:

```
# plot the training and validation accuracy

N = np.arange(0, EPOCHS)

plt.style.use("ggplot")

plt.figure(figsize = [10,8])

plt.plot(N, H.history["accuracy"], label="train_acc")

plt.plot(N, H.history["val_accuracy"], label="val_acc")

plt.title("CNN: Training and Validation Accuracy")

plt.xlabel("Epoch #", weight="bold")

plt.ylabel("Accuracy", weight="bold")

plt.legend()

plt.show()
```





Prediction code:

```
def predict_image(image):
    # load the image


    # pre-process the image for classification

    image = cv2.resize(image, (28, 28))

    image = image.astype("float") / 255.0

    image = img_to_array(image)

    image = np.expand_dims(image, axis=0)



    preds = model.predict(image)[0]

    result = dict()
```

```
    result["fertility coefficient 1"] = round(float(list(preds)[0]), 6)

    result["fertility coefficient 2"] = round(float(list(preds)[1]), 6)

    result["fertility coefficient 3"] = round(float(list(preds)[2]), 6)

    result["fertility coefficient 4"] = round(float(list(preds)[3]), 6)

    result["fertility coefficient 5"] = round(float(list(preds)[4]), 6)

    result["fertility coefficient 6"] = round(float(list(preds)[5]), 6)


    print(result)


    return result
```

Testing code:

```
import cvzone
import cv2
from cvzone.ClassificationModule import Classifier

cap = cv2.imread(0)
myclassfier = cvzone.Classifier("my_model.h5","labels.txt" )
fpsReader = cvzone.FPS()
while True:
    _, img = cap.read()
    predictions, index = myclassfier.getPrediction(img)
    fps = fpsReader.update()
    print(fps)

    cv2.imshow('image',img)
    if cv2.waitKey(10) & 0xFF == ord('q'): # Break gracefully
        break
cap.release() # release our webcam
cv2.destroyAllWindows() # close down our frame
```

5. Conclusion

We have taken this project as an experiment to check the quality of the soil near Yamuna river and we tried testing a new way to do the easy and simple testing of the soil for its toxicity and fertility. As a result of this experiment we have found that the Polluted water of the Yamuna river affects the fertility of nearby land. It also affects the growth of the plants grown near the yamuna river and its yield. Our sampling test gave us really clear results showing the growth of the plant was lowest in the sample which was taken from the bank of the river and was increasing with the increase in the distance. Same Hypothesis was supported by the lab testing result from which we found that the carbon content in the soil was lowest in the sample of the bank soil whereas it was increasing with increase in the distance. Our image processing program gives us really good results in the calculation of the total decomposition done on the cotton sample placed in the soil. whereas the machine learning model works with 83% accuracy in the prediction of the fertility coefficient. So to conclude we can say that our experiment in testing a new way to check the fertility and the toxicity of the soil was a great success and can provide really good results without any chemical involvement and lab testing.

5.1. Future Scope:

In the near future our plan is to improve the accuracy of our solution and also to improve it as a commercial solution. As we have tested a new way of testing the toxicity it can also be used to check the fertility and the toxicity of other area soil. So our next step will be to make our solution compatible with other soil types. Right now this solution is only tested on the soil of the Delhi area and the soil near the Yamuna River bank. We have a strong belief that this solution has a very good scope in the future to solve a bigger pollution problem at ground level.

Reference:

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