

Physico-chemical Analysis of Sugar Mill effluents and their effects on Leguminous Plant growing in North Bihar

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Manuscript received online 28 March 2025, accepted on 25 April 2025

Abstract : In India, North Bihar is primarily known for agricultural activities. It is specially recognized as sugarcane growing area that led to the growth of large number of sugar mills. Narkatiaganj sugar mill is one of them. It is discharging effluents in open drains through which it is directly connected to rivers. The adjoining areas of the factory are famous for their Pea (*Pisumsativum*L.) growing region. This led to the selection of pea plant as a test species of this research project. Two well-known varieties of *Pisumsativum*L. named as Arkel and Azad-1 were selected to study the effect of effluents discharging from sugar mill. Physico-chemical analysis of sugar mill effluent, collected from Narkatiaganj were analyzed to ascertain the composition, particularly with reference to pH, Temperature, Conductivity, Turbidity, DO, BOD, COD, Phosphate, Total Solids, Nitrogen, Alkalinity, Free CO₂, and Potassium. All the parameters were observed to be higher than the usual limit.

The effect of the effluents on the *Pisumsativum*L. was studied for their germination, growth and reproductive behavior of the plant. It was marked that sugar mill effluents are very much responsible for low productivity of *Pisumsativum* L.

(Keywords : Physico-chemical, Sugar Mill effluents, Leguminous Plant).

Introduction

*Pisumsativum*L. belongs to the second largest family of Dicot with 600 genera and 1200 species¹. In India, it is well represented by 92

genera and 925 species². Edible seeds of *Pisumsativum*L. are known as pulses or beans. They are highly rich in proteins³ and is next only to cereals as a source of human and animal food. They also form excellent green manure crops and carry sufficient bacterial colony in their root nodules enabling them to utilize and fix atmospheric nitrogen. Since the aquatic system like river, pools, lakes etc. are the main source of water for irrigation in those areas, the pollutants are affecting the growth and reproductive behavior of pea plants. It is important to recognize that in recent years due to Green revolution, there has been an increase in the production of pulses in the country. Production of total pulses of country level is 1.26 crores tones, whereas in Bihar it is only 8 lakh tones. It is for this reason that efforts are being made to make a quantitative jump in their yield, especially *Pisumsativum*L. (Pea). In spite of these economic values, cultivation of *Pisumsativum*L. is at low level and sugar mill effluent is also a major cause for decrease in their productivity. That is why, this project has been undertaken to know the real cause and to suggest some solutions to increase the productivity of this important legume in North Bihar.

Experimental

Materials and Methods

Two varieties of *Pisumsativum* L. namely ARKEL and AZAD-1 were selected for experimental

purpose. Standard seeds of the two varieties were procured. Effluents of sugar mill were diluted to 100%, 75%, 50%, 25% and 10% by adding required volume of distilled water. The seeds were soaked separately in each of this concentration of effluent for 12 hours. Before sowing the seeds 12 eastern plots were especially prepared by filling with garden loam soil. They were irrigated with different concentrations of effluents and control with tap water.

Before the treatment of this plant with the effluents, the physico-chemical analysis of effluent was done in the laboratory. The various effects of these effluents on these two varieties of plants were studied especially their growth behavior.

Analysis of Effluent :

The following parameters were adopted for the analysis of the effluent:

1. **pH**-This was measured in the laboratory by systronics double electrode pH meter (model no.335) by electrometric method, where an electrode indicator was sensitive to hydrogen ion and pH independent reference electrode was used.

2. **Temperature** - The mercury thermometer having an accuracy of $\pm 0.2^\circ\text{C}$ was inserted in polythene jar containing effluent and the value in Celsius scale was noted. Three readings after 30 minutes interval were taken and the mean value was calculated in Celsius unit.

3. **Conductivity** - It was measured with the help of conductivity meter having a conductance cell containing electrodes of platinum coated with Pt. Black or Carbon. These electrodes are mounted and placed parallel at a fixed distance.

Calculation:

Conductivity = Observed Conductance \times Cell constant \times temperature factor at 25°C

4. **Total Alkalinity** - It was determined by direct titration of the samples with 0.1 N HCl first using phenolphthalein (pH - 8.3) and secondly in continuation with methyl orange (pH - 5.2) as an indicator. If the sample was neutralized with phenolphthalein, alkalinity was calculated

$$PA = \frac{A \times \text{Normality of HCL} \times 1000 \times 50}{\text{ml of Sample}}$$

When phenolphthalein fails to neutralize completely, the sample was further treated with methyl orange (0.05%) indicator for complete neutralization and was calculated as

$$\text{Total alkalinity (As CaCO}_3\text{) mg/l} = \frac{B \times \text{Normality of HCl} \times 1000 \times 50}{\text{ml of Sample}}$$

Where'

B = ml of total HCl used with phenolphthalein and methyl orange

A = ml of HCl used with only phenolphthalein

PA = Phenolphthalein alkalinity

5. **Free CO₂** - It was estimated by titrating the sample with NaOH (0.05 N). Phenolphthalein was used as indicator. All the CO₂ at pH 8.3 is covered into bicarbonate. The value of CO₂ was estimated as per formula given below :

$$\text{Free CO}_2 \text{ mg/l} = \frac{(\text{ml} \times \text{N}) \text{ of NaOH} \times 1000 \times 44}{\text{ml of sample}}$$

6. **Dissolved Oxygen** - This was determined by Winkler's Iodometric method in which iodine can be titrated against thiosulphate using starch as an indicator. The sample was collected in a brown glass bottle at the sampling station avoiding any kind of bubbling. The preservatives were used in form of 2 ml each MnSO₄ and alkaline KI solution. As precipitate appears, the sample is carried to the laboratory. After proper shaking the bottle, it was left sometime for settling the precipitate. Then 2 ml of H₂SO₄ is added and was shaken well to dissolve the precipitate. After that 100 ml of this solution was taken in conical flask and titrated against sodium thiosulphate solution

using starch as an Indicator. At the end point, initial dark blue colour changes to colour less.

Calculation

$$\text{Dissolved Oxygen mg/l} = \frac{(\text{ml} \times N) \text{ of titrant} \times 1000 \times 8}{V_1 - V}$$

Where, V_1 = vol. of total sample,
 V = vol. of conc. sample

7. Chemical Oxygen Demand (COD) - It is the measure of oxygen consumed during the oxidation of oxidizable organic matter by strong oxidizing agent. Potassium dichromate in the presence of H_2SO_4 was used as an oxidizing agent for determination of COD.

The COD is estimated by titration method by titrating the excess of Potassium dichromate against Ferrous Ammonium Sulphate using Ferroin as an indicator. The amount of $\text{K}_2\text{Cr}_2\text{O}_7$ was used in proportional to oxidizing organic matter present in the sample.

20 ml of the sample in a COD flask of 500 ml (round bottle flask with a ground for Leibig reflux condenser) was taken and to that 10 ml of 0.025 N Potassium dichromate solution was added. A pinch of Ag_2SO_4 and HgSO_4 and 30 ml of H_2SO_4 was then added. It was then refluxed for 2 hours on a water bath. After refluxing the flask was removed, cooled and distilled water was added to make the final volume to make 140 ml. After that 2-3 drops of ferroin were added as an indicator and mixed thoroughly. This was titrated with 0.1 N Ferrous ammonium sulphate. A blank titration was calculated with distilled water using same quantity of the chemicals.

Calculation:

$$\text{COD mg/l} = \frac{(a - b) \times N \text{ of } \text{K}_2\text{Cr}_2\text{O}_7 \times 1000 \times 8}{\text{ml of sample}}$$

Where

a = ml of titrant with sample.

b = ml of titrant with blank

8. Potassium - Flame photometric method was employed to evaluate total potassium. The characteristic radiation for potassium is 768 nm. The intensity was read on a scale by using a filter for the wavelength.

$$\text{Potassium mg / l} = \text{mg / l k in diluted aliquot} \times \text{dilution factor}$$

9. Sodium - It was estimated by flame photometric method. A characteristic light is produced due to the excitation of electrons when the sample containing sodium is sprayed over the flame. The intensity of characteristic ratio is proportional to concentrations of the sodium and can be read at 589 nm by using suitable filter.

$$\text{Sodium mg / l} = \text{mg / l Na in diluted aliquot} \times \text{dilution factor}$$

10. Inorganic Phosphate - It was estimated by spectrophotometric method. The phosphorous in water reacts with Ammonium molybdate and forms a heterophylic acid (molybdophosphoric acid) complex, which gets reduced to a complex of blue colour in presence of SnCl_2 . The absorption of light by blue colour was measured at 690 nm to calculate the concentration of phosphate.

11. Total Nitrogen - It was measured or estimated by Micro - Kjeldahl method. The sample was digested with H_2SO_4 and potassium sulphate which converts all the organic nitrogen ammonia into sulphate. Most of the forms remain unaffected. NaCl was added to prevent partial reduction of nitrate to ammonia, which converts the NO_3 into NaCl . The Nitrogen in the form of Ammonium sulphate can be determined by distillation at higher pH. 4 ml of H_2SO_4 , 10 drops of CuSO_4 solution, 6 gram solid Potassium sulphate and 1 ml of 10% NaCl solution were added to 40 ml of sample in 100 ml Kjeldahl flask, which was heated for 40 minutes and then cooled. Volume in the flask was made 100ml. Digest was neutralized with 5N NaOH using phenolphthalein as an indicator. After the neutralization, the volume was made 100 ml with distilled water. 25 ml of digest was taken and

distillation was performed adding 10 ml of 10N NaOH. A separate blank with distilled water was used for the same amount as that for the chemicals. Distillate was titrated with 0.01N HCl until the colour changes from blue to brown. The amount of Nitrogen was estimated as per formula given below:

$$\text{Kjeldahl N mg/l} = \frac{(a-b) \times 0.01 \times 1000 \times 14 \times D}{\text{ml of sample distilled}}$$

Where,

a = ml of HCl used with sample

b = ml of HCl used with blank

D = dilution factor (2.5) The original volume of the sample has been made 100 ml after digestion.

12. Oil and Grease

It was estimated in Petroleum ether which is immiscible in water and can only be separated through funnel. The residue left after evaporation of petroleum is oil and grease. Sample for experiment of oil and grease was collected in a wide bottle separately and entire sample without sub - division for analysis was used. The sample was taken in a separatory funnel. 10 ml of H₂SO₄ (1:2 distilled water and 50 ml of petroleum ether) were added to the sample. Lower portion of suspension was discharged after shaking the mixture thoroughly. The petroleum ether was run through a petroleum moist paper into a pre-weighted small beaker and evaporated. There after the fixed weight was taken to evaluate the amount of oil and grease as per formula given below:

$$\text{Oil and Grease (mg/l)} = \frac{(A - B) \times 10,00,000}{V}$$

Where,

A = fixed wt. of disc in gm

B - Initial wt. of disc in gm.

v = volume of sample taken in ml.

13. TDS (Total Dissolved and Suspended Solids)

It is done in three parts

- Total Solids
- Total dissolved solids
- Total suspended solids

Total Solids - were estimated as the residue left after evaporation of the unfiltered sample as given below:

$$\text{Total Solids mg/l} = \frac{(A - B) \times 10,00,000}{V}$$

Where,

A = Final weight of the dish in gm.

B = Initial weight of the dish in gm.

V = Volume of sample taken in ml

b. **Dissolved Solids** - were estimated as the residue left after evaporation of the filtered sample as given below:

$$\text{Dissolved Solids mg/l} = \frac{(A - B) \times 10,00,000}{V}$$

Where,

A = Final weight of the dish in gm.

B = Initial weight of the dish in gm.

V = Volume of sample taken in ml

c. **Total Suspended solids** - were estimated as the difference between the total solids and the total dissolved solids.

$$\text{T.S.S mg/l} = T.S - T.D.S$$

Observations

The physico-chemical analysis of sugar mill effluents are known to contain organic and inorganic substances above the permissible level and hence considered toxic for both flora and fauna of that region. After observation and analyzing the physico-chemical features of Narkatiaganj sugar mill effluents, the data are incorporated in Table-01. Sampling was done from discharging point and was analyzed in mg/l for all parameters except pH and Temperature in the month of December, February and March.

Table-01
Physico-chemical features of the effluents of sugar mills of Narkatiaganj

S.No.	Parameters	December	February	March	Mean
1.	pH	4.6	4.5	4.4	4.5
2.	Temperature °C	44.0	45.0	46.0	45.0
3.	Conductivity(mho/cm ²)	0.514	0.515	0.517	0.515
4.	Total Alkalinity	101	102	105	102.6
5.	Free CO ₂	26.0	25	24	25.0
6.	Turbidity (NTU)	75.0	85	77	78.06
7.	TS	1250	1300	1400	1300
8.	TDS	1035	1040	1045	1034
9.	TSS	259	260	265	261
10.	DO	0.7	0.5	0.4	0.5
11.	BOD	1035	1040	1045	1035
12.	COD	1125	1080	1150	1118.3
13.	Nitrogen	26	27	29	27
14.	Phosphorous	3.6	3.8	3.9	3.7
15.	Potassium	84.2	85.5	86.2	85.5
16.	Oil and Grease	79.6	76.5	77.2	77.7

From the above mentioned data, following observation and analysis have been derived.

pH and Temperature - pH

value lies in range of 4.2 and 5.3 which indicates the acidic nature of the effluent. Temperature is directly related with the biological and chemical process of the system. The mean value of the temperature of effluent varies from 44°C to 46°C.

Conductivity

Electrical conductance is the ability of the substances to conduct the electrical current. In water, it is the ability caused by the presence of various ionic species. In presence conductivity lies in the range of 0.514- 0517 mho/cm².

Total Alkalinity

It is the amount of free hydroxyl ions present in the medium. In the present case, the alkalinity lies in range of 101-105. The total alkalinity along with pH plays an important role in controlling the biological system.

Free CO₂

The parameter is very much dependent upon alkalinity, pH and temperature of the aquatic system. The mean value of free CO₂ ranged from 24 to 26 mg/l.

Dissolved Oxygen (DO)

DO is the main parameter of water quality which indicates the physical and biological processes going on in the water. Aquatic organisms have specific demands of O₂ and its absence may prove to be lethal for them. At the discharge point, DO was very low. It ranged between 0.4 to 0.7 mg/l. However, in the month of December DO was observed to be 0.7 ppm.

Biological Oxygen Demand (BOD)

It is the measurement of degradable organic material present in the water. It can be defined as amount of oxygen required by the microorganism in stabilizing the biological degradable organic matter under the aerobic

condition. In the presence case BOD ranges from 1035 to 1045 mg/l.

Chemical Oxygen Demand (COD)

COD is concerned with oxidation of organic compounds in water. CO estimation in water having toxic chemicals become useful as variation in COD value will control the growth of microorganism. In present case it lies in the range of 1080 to 1150 mg/l.

Potassium

The higher value of Potassium is the characteristic features of the sugar effluent. In our study its value ranged from 84.0 mg/l to 86.2 mg/l.

Inorganic Phosphorous

It plays an important role in controlling the nutrient budget of the aquatic system. In present case phosphorous along with higher nitrogen is playing vital role in controlling the biological system of the aquatic media. It ranged from 3.6 to 3.9 mg/l.

Total Nitrogen

It ranged from 27 mg/l to 29 mg/l in effluent of sugar mill. Similar to other parameters no marked seasonal variation was observed.

Total Solids (TS)

Table 1 illustrates the variation in the amount of TS from 1250 mg/l to 1400 mg/l. Higher TS is one of the main features of sugar industry effluent.

Total Dissolved Solids (TDS)

In our study it varied from 1035 to 1045 mg/l with mean value 1034 mg/l. It also showed the same trend as those of total solids. The mean value was significantly high.

Total Suspended Solids (TSS)

Sugar industry effluents are known for higher value of solids, out of which TSS

constitutes significantly proportion. It varies from 259 to 265 mg/l.

Turbidity -

It is measurement of suspended particle of the effluent. It ranges from 74 to 85 NTU. The value was very high, showing the load of pollutants.

Oil and Grease

It is released during crushing of the sugarcane. It forms thin film over the aquatic body. In the present case higher quantity of release of oil and grease was noticed that ranged from 76.5 to 79.6 mg/l.

Discussion:

The physico-chemical analysis of effluents was carried out in two varieties of *Pisumsativum*L. The water quality is so important that it immediately catches the attention about pollution. There is no doubt that the pollution of water is responsible for a number of mortalities and incapacitation in the world. Polluted state of water resources and its declining effects culminating in modern age, as water no large remain a "free good"⁴. Availability of clear water is going to become the greatest constrains of development of tomorrow. The deterioration of water quality as a result of human activities is phenomenal.

Today most of the world receives millions of litres of sewage, domestic waste, industrial and agricultural effluents containing substances varying in characteristics from simple nutrients to highly toxic substances⁵. Basic type of pollution namely (a) Non-degradable and (b) Biodegradable has been recognized⁶. The nature of pollution depends upon the nature of raw materials used during manufacturing and maintenance of industries, most of which discharge their toxic effluents in river, pond and in open field. The nature of toxicity depends on the process of manufacturing and chemical used.

Toxicity of distilled waste is inversely proportional to the conductivity, bicarbonate and alkalinity of medium⁷. Toxicity has been attributed to the occurrence of sulphate⁸. Toxicity of industrial effluents reveals serious toxic effect on many field species due to liberation of halogens⁹. Ammonia (NH₃) and Nitrogen dioxides (NO₂) contents discharge by fertilizer factories have been found responsible for its toxic effects on growth of leguminous plants¹⁰.

Paper mill effluent contains sulphides, sulphates, sulphuric acid, other mixtures are also harmful for growth of plants¹¹. The waste water from oil refinery contains Ammonia ion which are much toxic to the fishes¹².

Several other workers have studied the nature of pollution caused by domestic as well as industrial waste contains organic and inorganic salts and other toxic substances.

The waste water is discharged by most of the industries without any treatment. The effluents may induce undesirable alternation in the physico-chemical or biological characteristic of water and soil that may influence the organism living under the stress of environmental pollution.

Physico-chemical properties are influenced by number of parameters. The parameters like pH, Temperature, Alkalinity and Free CO₂ are guided by their natural relations. Alkalinity of aquatic systems in the present case is the measurement of free OH ions which is guided by pH as well as the Ca content of the aquatic system¹³. In the present total alkalinity lying in the range of 102 ppm indicates the proper functioning of buffer system of the aquatic system. Free CO₂ is also influenced by pH are in the acidic range thereby favoring higher range of free CO₂. Nitrogen, Phosphorous and Potassium are interdependent and influenced by the other factors. Nitrogen (27mg/l) along with Phosphorous (3.8mg/l) and higher Potassium, to

some extent, signify the fulfillment of nutritive requirement of the plant¹⁴.

Narkatiaganj sugar mill is a sulphination plant. It releases excessive CO₂ during crushing season thereby making the effluent highly acidic. At the discharging point the temperature lies in the range of 45°C. The excessive temperature coupled with acidic nature of effluent are an indicator of toxic nature of effluent.

DO was observed to be almost nil. DO has a significantly negative correlation with temperature. Higher the temperature lowers the DO¹⁵. In the present case the higher range of temperature is sufficient to deplete the DO to nil. Suspended solids have been found to be higher. Normally, it results into higher turbidity (78.6 NTU) and increase the benthic BOD. It also interferes with photosynthesis by preventing sunlight being transmitted through the aquatic system¹⁶.

Oil and Grease are immiscible in water and being low in density floats on the surface of water and thereby interfere with respiration and movement of the zoo-organism. It causes clogging of stomatal opening of mesophytes. The presence of oil and grease, very high T.S. (Total Solids) and absence of DO show the toxic nature of the effluent. Phosphorous is also useful to the plants. It is considered as bio stimulant in addition of Nitrogen and good influence on aquatic productivity¹⁷.

The concentration of phosphorous indicates the pollution load¹⁸. The prime concern of phosphorous lies in the ability to increase the growth of nuisance algae and eutrophication.

COD/BOD ratio slightly higher than one indicates that the pollutants are primarily organic in nature. In some of sugar mill effluents higher ratio has been observed.

The physico-chemical analysis of sugar mill effluents responsible for biological damage and less percentage of germination of root and shoot length. Several workers have demonstrated drastic effect of various industrial effluences on germination and growth pattern of several plant species^{19,20}.

It is clear that sugar mill effluents adversely affect the germination and seedling growth. It is reported that radicle inhibition is due to disturbance in physico-chemical processes such as inhibition, osmosis of water, respiration; therefore, these chemicals are capable of interfering with metabolic processes. These are the major causes that % of production of pea plant in is greatly reduced.

It must be taken seriously to overcome the problem. Effluent is mutagenic also in nature,

thus high efficient schemes may mayenhace the yield of *Pisumsativum* L. in the regions of Narkatiaganj.

Conclusion

The results of the present study indicated that sugar mill effluents which are to nearby land, may affect the soil properties. The sugar mill effluents also improve EC (Electrical Conductivity) and sulphur content of the soil. There is considerable concern about 'P' being lost from soil and transported to nearby streams. So, the perusal of results conclude that at one side it improves the soil quality by increasing the Electrical Conductivity of the soil but on the other side add high concentration of Potassium and Sulphur damaged the soil.

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