

## Effect of Industrial Effluents on Seed Germination and Seedling Growth of Mustard, Gram and Wheat: A case Study of National Fertilizers Limited, Vijaypur (Madhya Pradesh)

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### ABSTRACT

Water is the vital for existence of life on planet. However, water resources have been subjected to different level of ecological stress for decades. This stress is a result of increasing industrial activities, rapid urbanization, population explosion and green revolution. Out of all the sources of stress, discharge of industrial effluents into rivers and other water bodies has affected crop and other vegetation. Problem of water pollution in Rajasthan and M.P. is becoming more serious due to limited water resources and increasing industrialization. Very few studies have been carried out to investigate effect of discharge effluents into the rivers in the region. Investigations have suggested that the crops and vegetation is affected adversely due to effluent waters being discharged into rivers. Here, investigation on effect of effluent discharge from National Fertilizer Limited, Vijaypur, Guna, Madhya Pradesh on seed germination and seedling growth (size of seedling chlorophyll and carotenoid content of seedlings) on crops are presented. Three major crops namely, Mustard, Wheat and Gram were chosen for the study. Study was carried out from August 2010 to September 2011. Main polluting agents present in the effluent were Calcium, Magnesium, Alkalis, and some metals. It was observed that in seedling growth the inhibitory effect was more prominent on the radical growth rather than that of hypocotyl. On a comparative basis the inhibition of seedling growth was more pronounced in gram followed by mustard and wheat. We also observed marked decrease in pigment concentration of the seedlings.

Keywords: *Effluents, Germination, Seedling Growth, Pigment Concentration*

### I. INTRODUCTION

Water is essential for existence of life and vegetation. Only a small fraction of total available water is suitable for human consumption and economic activities viz. irrigation, industrial usage. Usable water is stored as ground water, lakes and also flows through rivers on the surface. Most of the industrial estates have come up near the rivers. In most of the cases, effluents (treated, partially treated and untreated) are discharged into the nearby rivers. This results in changes in original characteristics of the water. This in turn affects the crops which use this water for irrigation. The land around these rivers is also affected due to presence of chemicals and metals in the effluents.

Life in an aquatic ecosystem is directly or indirectly dependent on water quality. The alteration in physico-chemical characteristics of water affects the biota in terms of number and diversity. Today, most of the ecosystems of the world receive millions of liters of sewage, industrial and agricultural effluents containing materials from simple nutrients to highly toxic substances. Changes in the aquatic environment accompanying anthropogenic pollution are of great growing concern and require monitoring of surface water.

The Indian subcontinent is a distinct biogeography region. It is unique in its geological history, geomorphology, climate and biota. Fresh water ecosystem in Indian subcontinent is estimated to have an area of about 1.37 million hectare [1]. The geographical position and morphology of land of our country has resulted in uneven temporal and spatial distribution of waterscape resources [2]. The rain water or surface run-off water collects in innumerable small and large depressions scattered all over the country which provide attractive areas of research for biologists.

Industrial revolution has been a great boon to mankind. However, there is a wide range of environmental impacts created by industries. Majority of industries are water based. 75% of the fresh water drawn by the domestic and industrial effluents inevitably end up in surface water bodies or in the ground water affecting the water quality. Though the industrial use of water is very limited in comparison to the agricultural use, the disposal of industrial effluent on land or surface water bodies make water resources unsuitable for other purposes [3].

Entry of pollutants in the flowing stream or rivers sets off a progressive series of physical, chemical and biological events within the downstream water. The nature of polluted water body is thus governed by the quality and quantity of the polluting substances. Domestic or industrial effluents may adversely affect the natural stream life by direct toxic action or indirectly through quantitative alteration in the characteristics of the water or the stream bed.

Problem of environmental pollution on account of essential industrial growth is due to the problem of disposal of industrial waste as well whether solid, liquid or gaseous. Polluted water directly affects soil not only in industrial areas but also in agricultural fields and river beds, thereby creating secondary source of pollution [4].

Diverse nature of agro-based industrial effluents from various industries are disposed off into soil and water bodies. This has been causing major pollution problem. Indiscriminate use of water affected by industrial effluents for irrigation may reduce crop growth and contaminants may interfere with natural characteristics of soil [5].

Effluents, if directly discharged without any treatment into the nearby water body, results in (i) increase or decrease of water pH, increase in (ii) temperature, (iii) Biological Oxygen Demand (BOD), (iv) Chemical Oxygen Demand (COD), (v) heavy metals, and, (vi) toxic chemicals [6].

Effluents released with high temperature can raise the temperature of water body, thus reducing the solubility of oxygen in the water resulting in an increase of the pH of the receiving water body.

Water plays an important role to cause effects of pollution because it allows pollutants to accumulate in it. At the downstream point of industrial areas water quality becomes useless to the extent that it is unfit for drinking and is often a disease carrier. Some pollutants like discharge of heated coolant water and radioactive effluents are physical factors, but they exert a marked influence on the bio-chemical reactions.

National Fertilizers Limited (NFL) is located at Vijaypur village on the left bank of Chopan River in Raghogarh sub. district of Guna district of Madhya Pradesh, India. The Plant commissioned in Dec. 1987 comprises of one Ammonia Plant of 1350 MT/day and Urea Plant of 2200 MT/day in two streams of 1100 MT/day. The commercial production from the plant started in the year 1988. The second phase of the Plant with equal capacity (Line II) came into commercial production in March 1997. The plant covers an area of 506 hectares with fertilizer Complex Township and demonstration farming unit. Effluents from the plant are finally discharged (untreated or partially treated or after treatment) into the Chopan River. The Chopan River water meets Parvati River after travelling approximately 3 Kms. The Parvati River finally joins the Chambal River.

The main polluting agents in such type of industries are ammonical nitrogen, heavy metals, refractory organic compounds, residual chlorine, caustic soda. This affects the Biological Oxygen Demand and Chemical Oxygen Demand of the water body. Discharge of treated or untreated effluents leads to ground water contamination and leaching of pollutants into the nearby crop fields. Presence of salts in higher concentration in soil from industrial effluents curtails the soil water uptake of plants and inhibits the growth of plants [7].

The present study has been undertaken to observe the extent of water pollution surrounding the areas of the plant over a period of one year from August 2010 to September 2011. We have investigated the extent of pollution and its impact on germination and seedling growth (size of seedlings chlorophyll and carotenoid content of seedlings) of selected crop plants. The study includes the analysis of physico-chemical characteristics of effluents from NFL. Three crop plants viz gram (*Cicer arietinum* Linn.) mustard (*Brassica campestris* Linn.) and wheat (*Triticum aestivum* Linn.) were studied.

## II. LITERATURE REVIEW

Germination is a critical stage. This ensures reproduction and consequently controls the dynamics of population. This makes it a critical test for the probable crop productivity [8]. Germination is defined as “the resumption of active growth by embryo resulting in the rupture of

seed coat and emergence of plant". Effluent released into the environment without proper treatment alters the characteristics of ecosystem. Farmers using these effluents for irrigation found that growth yield and soil health has been reduced [9]. Fertilizer industry is one of the major water consuming industries, responsible for water and soil pollution of considerable magnitude [10]. Diluted form of paper mill effluent could be used for irrigation purpose to enhance production of agricultural crops [11].

Oberai [12] studied effects of combined effluent of Tara Export, Deva Suiting, Sai Paper mills and Choudhary Food Factory which joins the river Kshipra at Havankheddi. He has studied the effects of different dilution of the effluent on seed germination of Wheat variety mexicana, sabarmati and pusa savani. Saxena et al. [13] studied the effects of seed germination and seedling growth in 4 pulse crops. They observed inhibitory influence of dyeing and textile effluent of Pali in cicer arietinum Linn. Effluent of fertilizer factory Gorakhpur was observed to correspondingly decrease in seed germination, speed of germination index with increase in effluent concentration and complete inhibition at 75-100% treatment in Brassica oleracea Linn. variety botrytis [14]. Srivastava [15] evaluated the paper mill and chlor-alkali plant effluent (CAP) on seed germination of healthy seeds of radish and onion in different dilution of effluents and revealed that the percent germination was more with lower concentrations of the effluents when seeds treated for one to five days each. In the case of radish, at 10% concentration of the effluents, there was a significant decrease in mean root length, shoot length and secondary roots as compared to control while no secondary root could emerge out in 100% concentration of CAP effluent. Low dissolved oxygen associated with high mercury and residual chlorine content in effluent affected adversely the germination and subsequent growth of seedlings. Considerable literature is available on the effect of fertilizer factory effluent on seed germination and seedling growth of crop plants [16].

Karunyal et al. [17] studied the effects of tannery effluent at different concentrations on seed germination of *Oryza sativa* and observed the inhibitory effect on higher concentration of effluent. Studies on physico chemical characteristics of the untreated effluents of Pravara pulp and paper mill and Pravara Distillery and its effect on germination and early seedling growth of pigeon pea (T-211) were carried out by Karande and Ghanvat [18]. The distillery effluents when employed as it is or diluted, elicited the significant deleterious effect on seed germination and early seedling growth of pigeon pea (T-21). Combined effect of wastes of distillery and sugar mill on seed germination, seedling growth and biomass of *4beimosehus esculentus* Linn. moench, was studied by Om Hari et al. [19]. They observed that germination percentage, seedling growth and biomass increased up to 80% effluent concentration. Germination was completely inhibited in 100% effluent concentration. While studying combined effect of different concentrations of wastes of distillery and sugar mill, inhibition of seed germination, seedling growth and biomass in Okra (*AbelmoschuS esculentus* Linn. ) was observed. The effects of different concentration of distillery effluent on germination of three multi useful tree species,

Acacia catechu, Dalbergia sissoo and Morus alba, which grow abundantly under tropical and sub tropical climatic conditions were examined by Pandey et al. [20]. They observed that an effluent concentration of 10% was more favorable for seed germination as compared to ordinary water.

Zalawadia et al. [21] studied the inhibitory effect of distillery effluent in combination with fertilizer on plants as well as on soil properties. Kaushik et al. [22] reported that low concentrations of sugar factory effluent have no effect on seed germination of *Triticum aestivum* Linn. Experiments conducted by Dutta and Biossya [23] for studying the effect of low concentration of paper mill effluent on growth and field NPK contents in rice showed increase in growth and yield of crop. Sundara moorty P. [10] observed toxic effect of a fertilizer factory effluent on seed germination, seedling growth and dry weight of grass, black gram, ground nut, soybean, paddy and sorghum. Undiluted effluent had an inhibitory effect where as the lower percentage of effluent concentration was found to be a growth promoting effect, which was significantly better than control. Beyond 10% effluent concentration, seedling growth decreased positively. The effluent can be used safely for irrigation purpose after proper dilution for beneficial cultivation of crops.

Municipal waste water has been found to cause more water on chromosomal aberration than the extract from *Parthenium hysterophorus*. Untreated effluents are highly toxic to the plant, fishes or other aquatic organisms at higher pH and the sulphide in the effluents are of environmental concern [23]. Effect of factory effluents on seed germination and seedling growth of *Vigna radiatus* were studied by Angusthy [24], Nath and Sharma [25], reported that the lower concentration of sugar factory effluent increases the seedling growth, chlorophyll and amylase contents in green gram (*Phaseolus radiatus* Linn.) seedling in a 10 days experiment.

Textile industry is an important contributor to national economy. Due to rapid changes in customer's demands, textile finishing industries challenged to use high quantity of dyes and auxiliaries [26]. Effluents generated by the industries are one of the sources of pollution. Contaminated air, soil and water by effluents from the industries are associated with disease [27]. Heavy metal contamination of soil and vegetables in areas of Varanasi was studied by Sharma et al. [28]. The study concluded that the use of treated and untreated waste water for irrigation has increased the contamination of Cu, Cd, Pb and Ni in edible portions of vegetables causing potential health risk in the long term.

Industrial effluent and health status: A case study of Noyyal river basin [29] reported that the impact of water pollution was significant on the rural community in the areas of health, agriculture, live stock and drinking water. Singh et al. [30] revealed the effect of fertilizer factory effluent on seed germination, seedling growth and chlorophyll content of gram at different concentrations and observed that the effluent could be used safely for cultivation of gram, after proper treatment and dilution. Physico- chemical Analysis and effect of distillery effluents on

seed germination of *Triticum aestivum*, *Pisum sativum* and *Abelmoschus esculentus* was investigated by Pandey et al. [31]. In this study germination percentage decrease with increasing concentration of effluent in all the tested seeds whereas the germination speed, peak value and germination value increased from control to 25% and 50% concentration and decreased from 50% to 75% and 100% effluent. Muthalagi and Mala [32] found that 100% sewage concentration on *Brassica nigra* (mustard) reduced the germination, length of root and shoot from 42 to 32% 2.10 to 1.49 cm and 2.08 to 1.49 cm, respectively. This study has indicated that 10% sewage showed maximum germination, shoot length and root length. Singh et al. [33] observed that the percentage germination and seedling vigour of rice and wheat decreased significantly with an increase in spent wash concentration. Malaviya and Sharma [34] studied the impact of distillery effluent on germination behavior of *Brassica napus* Linn. They observed the values for percent germination, germination index, germination value, speed of germination and peak value to be highest in 20% effluent concentration and lowest in 100% effluent concentration.

SA Begum et al [35] studied the effect of natural gas fertilizer factory effluent on germination and seedling growth of three leafy vegetables. They observed that the germination rate was decreased with increasing the concentration of industrial effluent. While studying the effect of dye factory effluent on growth, yield and bio chemical attributes of *Cleria arifinum* Linn, Kathirvel P. [36] stated that the best germination, seedling growth, number of root nodules, yield and bio chemical attributes was observed in 20% concentration with growth promoting effect and significantly better than control. However, beyond 20% effluent, root and shoot length decreased.

### III. METHODOLOGY

The effluents from National Fertilizers Limited, Vijaypur, Guna (M.P.) was collected between 8 and 11 hours and analyzed for various physico- chemical parameters according to the standard methods (APHA, 1975). The effluent collected was made into different dilutions by adding distilled water.

#### *Germination*

Seeds of gram, mustard and wheat crop plant were soaked for 6 hours in different concentration of the effluent. The soaked seeds were placed on moist whatmann number 1 filter paper in Petri dishes (10 Cm.) for germination in a growth chamber. The germination percent of each species was compared with a control set of seeds pretreated with distilled water. The Petri-dishes were kept moist by adding required amount of distilled water. Number of germinated seeds was noted every day. The criterion for germination was visual detection of radical emergence. The source of light was a bank of two incandescent bulbs of 60 watt each and fluorescent tube of 40 watt, fixed at a distance of 30cms from the dish level. The energy of light as recorded at the dish level

was  $2.6 \times 10^4$  erg/mm<sup>2</sup>/second. The entire set with three replicates of 20 seeds was repeated thrice.

### *Seedling growth*

Observations on the length of hypocotyls and radicle were made when the seedlings attained the age of 10 days. For pigment estimation, seedling samples were extracted in a mixture of acetone and ethyl alcohol in a ratio of 4:1 by volume. The amount of chlorophyll and carotenoids was determined by measuring the OD at 645, 663, 480 and 510 nm in a spectrophotometer model CL-24 (Elico). The values are expressed in terms of mg/100gm fresh wt. [ ].

#### IV. OBSERVATIONS

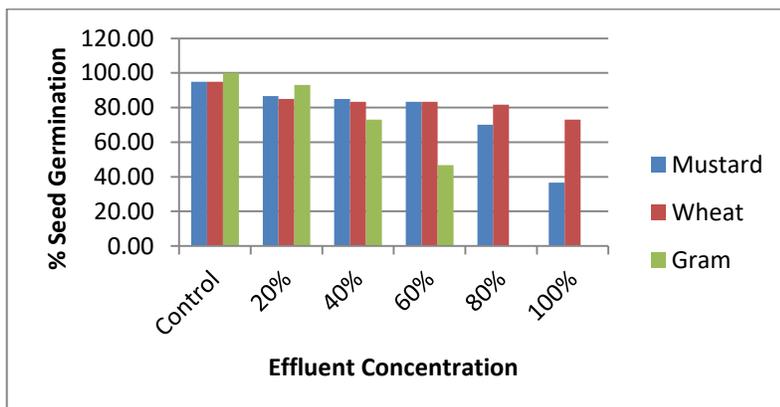
Physico- chemical characteristics of the effluents of NFL, Vijaypr are presented in Table 1.

| Table 1: Physico-Chemical Characteristics of Industrial Effluents at NFL, Vijaypur |   |      |                |
|--|---|------|----------------|
| S.No.  | Parameter   | Unit | Observed Value |
| 1.   | Colour  | -    | Light Brown    |
| 2.   | Odour   | -    | Ammonical      |
| 3.   | pH  | -    | 8.3-9.5        |
| 4.   | Turbidity   | NTU  | 5-35           |
| 5.   | Total Suspended Solids                              | mg/l | 16             |
| 6.   | Total Dissolved Solids                              | mg/l | 88-1428        |
| 7.   | Total Hardness (CaCO <sub>3</sub> )                 | mg/l | 100-600        |
| 8.   | Alkalinity Methyl Orange (CaCO <sub>3</sub> )       | mg/l | 380-700        |
| 9.   | Calcium Hardness (as CaCO <sub>3</sub> )            | mg/l | 32-320         |
| 10.  | Magnesium Hardness (as CaCO <sub>3</sub> )          | mg/l | 14-280         |
| 11.  | Chlorides   | mg/l | 28-140         |
| 12.  | Ammoniacal Nitrogen                                 | mg/l | 0.08-30        |
| 13.  | Nitrates (as NO <sub>3</sub> )                      | mg/l | 1.34-35        |
| 14.  | Fluoride  | mg/l | 0.20-0.9       |
| 15.  | Dissolved Oxygen                                    | mg/l | 5.1-6.07       |
| 16.  | Biological Oxygen Demand (5 days 20 <sup>0</sup> C) | mg/l | 0.5-2.06       |
| 17.  | Chemical Oxygen Demand                              | mg/l | 11.69-75       |
| 18.  | Metals  |      |                |
|  | Iron  | ppm  | 0.176          |
|  | Aluminium   | ppm  | 0.049          |
|  | Barium  | ppm  | 0.006          |
|  | Strontium   | ppm  | 0.036          |
|  | Nickel  | ppm  | 0.025          |
|  | Copper  | ppm  | 0.043          |
|  | Zinc  | ppm  | 0.011          |
|  | Manganese   | ppm  | 0.002          |
|  | Lead  | ppm  | Traces         |
|  | Cadmium   | ppm  | Traces         |
|  | Cobalt  | ppm  | Traces         |



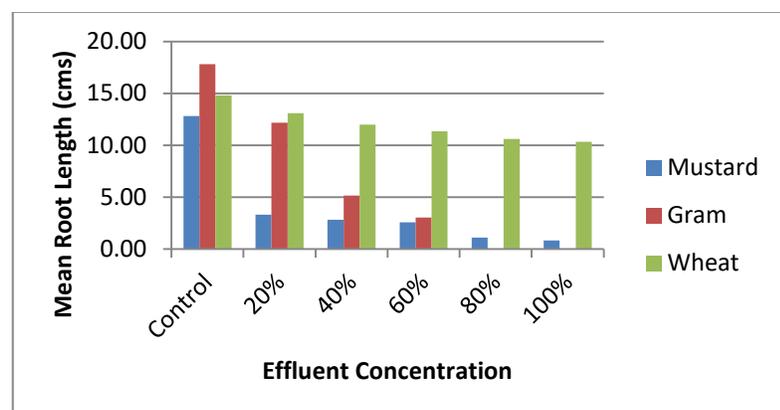
**Table 2: Effects of Industrial Effluents on % Germination of Mustard, Gram, and Wheat**

| Effluents Concentration | Mustard | Wheat | Gram   |
|-------------------------|---------|-------|--------|
| Control                 | 95.00   | 95.00 | 100.00 |
| 20%                     | 86.66   | 85.00 | 93.00  |
| 40%                     | 85.00   | 83.33 | 73.00  |
| 60%                     | 83.33   | 83.33 | 46.65  |
| 80%                     | 70.00   | 81.66 | 0.00   |
| 100%                    | 36.66   | 73.00 | 0.00   |



**Table 3: Effects of Fertilizer Effluents on Mean Root Length (cms) of Seedling of Mustard, Gram, and Wheat**

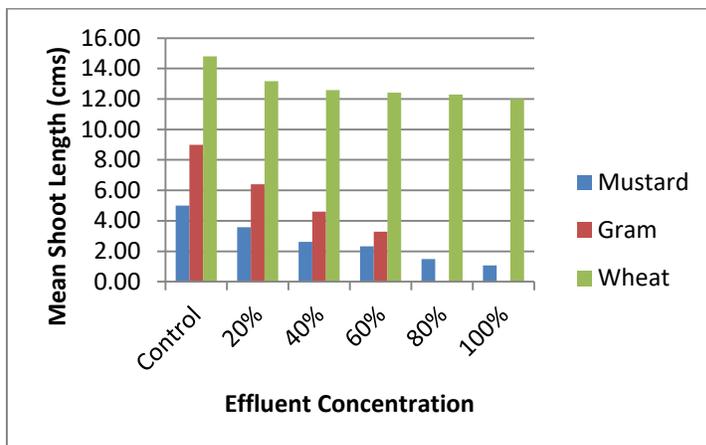
| Effluents Concentration | Mustard | Gram  | Wheat |
|-------------------------|---------|-------|-------|
| Control                 | 12.80   | 17.80 | 14.80 |
| 20%                     | 3.33    | 12.16 | 13.08 |
| 40%                     | 2.83    | 5.14  | 12.00 |
| 60%                     | 2.59    | 3.05  | 11.33 |
| 80%                     | 1.10    | 0.00  | 10.62 |
| 100%                    | 0.83    | 0.00  | 10.33 |



| <b>Anova Table (Mustard)</b>  |      |          |          |         |         |
|---|------|----------|----------|---------|---------|
| Effects of Fertilizer Effluents on Mean Root Length (cms) of Seedling of Mustard, Gram, and Wheat |      |          |          |         |         |
| Source of Variation   | D.F. | S.S.     | M.S.     | F       | P-value |
| Treatment   | 5    | 293.9940 | 58.7990  | 25.5796 | 0.0000  |
| Error   | 12   | 25.5840  | 2.1320   |         |         |
| Total   | 17   | 319.5780 |          |         |         |
| <b>Anova Table (Gram)</b>   |      |          |          |         |         |
| Source of Variation   | D.F. | S.S.     | M.S.     | F       | P-value |
| Treatment   | 5    | 773.6720 | 154.7340 | 65.7755 | 0.0000  |
| Error   | 12   | 28.2300  | 2.3540   |         |         |
| Total   | 17   | 801.9010 |          |         |         |
| <b>Anova Table (Wheat)</b>  |      |          |          |         |         |
| Source of Variation   | D.F. | S.S.     | M.S.     | F       | P-value |
| Treatment   | 5    | 42.9350  | 8.5870   | 3.8793  | 0.0253  |
| Error   | 12   | 26.5630  | 2.2140   |         |         |
| Total   | 17   | 69.4980  |          |         |         |

Table 4: Effects of Fertilizer Effluents on Mean Shoot Length (cms) of Seedling of Mustard, Gram, and Wheat

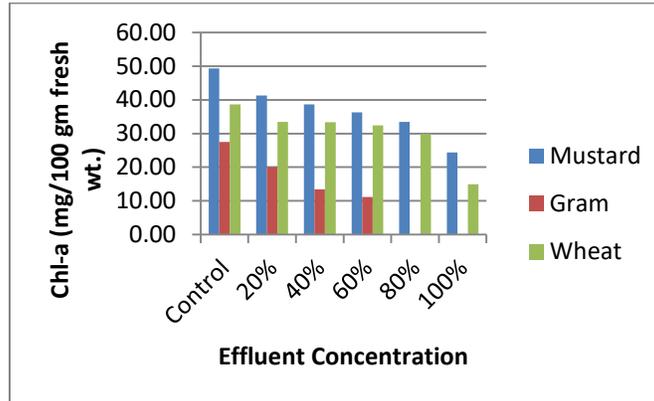
| Effluents Concentration | Mustard | Gram | Wheat |
|-------------------------|---------|------|-------|
| Control                 | 5.00    | 9.00 | 14.80 |
| 20%                     | 3.58    | 6.41 | 13.16 |
| 40%                     | 2.62    | 4.60 | 12.58 |
| 60%                     | 2.33    | 3.29 | 12.41 |
| 80%                     | 1.49    | 0.00 | 12.29 |
| 100%                    | 1.08    | 0.00 | 12.00 |



| Anova Table (Mustard) |      |          |         |          |         |
|-----------------------|------|----------|---------|----------|---------|
| Source of Variation   | D.F. | S.S.     | M.S.    | F        | P-value |
| Treatment             | 5    | 30.8040  | 6.1610  | 18.2527  | 0.0000  |
| Error                 | 12   | 4.0500   | 0.3380  |          |         |
| Total                 | 17   | 34.8540  |         |          |         |
| Anova Table (Gram)    |      |          |         |          |         |
| Source of Variation   | D.F. | S.S.     | M.S.    | F        | P-value |
| Treatment             | 5    | 190.8080 | 38.1620 | 145.6487 | 0.0000  |
| Error                 | 12   | 3.1440   | 0.2620  |          |         |
| Total                 | 17   | 193.9520 |         |          |         |
| Anova Table (Wheat)   |      |          |         |          |         |
| Source of Variation   | D.F. | S.S.     | M.S.    | F        | P-value |
| Treatment             | 5    | 15.5810  | 3.1160  | 2.8481   | 0.0638  |
| Error                 | 12   | 13.1300  | 1.0940  |          |         |
| Total                 | 17   | 28.7110  |         |          |         |

Table 5: Effects of Fertilizer Effluents on Chl-a (mg/100 fresh wt) of Mustard, Gram, and Wheat

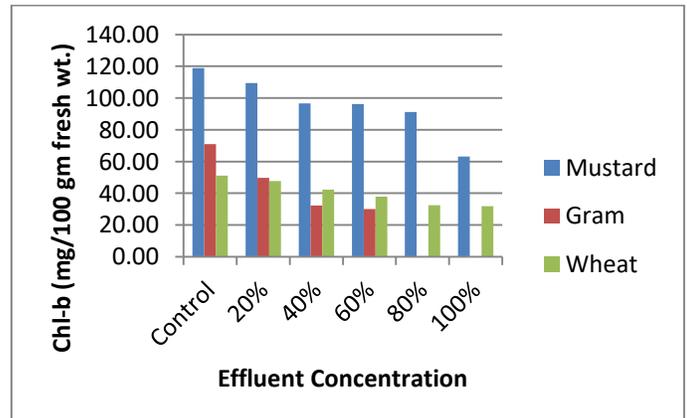
| Effluents Concentration | Mustard | Gram  | Wheat |
|-------------------------|---------|-------|-------|
| Control                 | 49.26   | 27.46 | 38.59 |
| 20%                     | 41.28   | 20.01 | 33.49 |
| 40%                     | 38.64   | 13.41 | 33.35 |
| 60%                     | 36.25   | 11.19 | 32.40 |
| 80%                     | 33.46   | 0.00  | 29.84 |
| 100%                    | 24.39   | 0.00  | 14.95 |



| Anova Table (Mustard) |      |           |          |         |         |
|-----------------------|------|-----------|----------|---------|---------|
| Source of Variation   | D.F. | S.S.      | M.S.     | F       | P-value |
| Treatment             | 5    | 1034.6210 | 206.9240 | 6.4222  | 0.0040  |
| Error                 | 12   | 386.6410  | 32.2200  |         |         |
| Total                 | 17   | 1421.2620 |          |         |         |
| Anova Table (Gram)    |      |           |          |         |         |
| Source of Variation   | D.F. | S.S.      | M.S.     | F       | P-value |
| Treatment             | 5    | 1781.5010 | 356.3000 | 34.3868 | 0.0000  |
| Error                 | 12   | 124.3390  | 10.3620  |         |         |
| Total                 | 17   | 1905.8400 |          |         |         |
| Anova Table (Wheat)   |      |           |          |         |         |
| Source of Variation   | D.F. | S.S.      | M.S.     | F       | P-value |
| Treatment             | 5    | 985.4920  | 197.0980 | 1.9660  | 0.1565  |
| Error                 | 12   | 1230.0650 | 100.2550 |         |         |
| Total                 | 17   | 2188.5560 |          |         |         |

**Table 6: Effects of Fertilizer Effluents on Chl-b (mg/100 fresh wt) of Mustard, Gram, and Wheat**

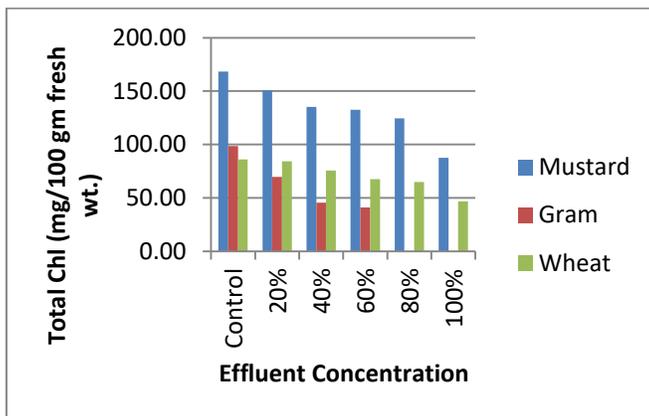
| Effluents Concentration | Mustard | Gram  | Wheat |
|-------------------------|---------|-------|-------|
| Control                 | 118.86  | 71.01 | 51.09 |
| 20%                     | 109.52  | 49.73 | 47.62 |
| 40%                     | 96.64   | 32.19 | 42.29 |
| 60%                     | 96.16   | 29.98 | 37.85 |
| 80%                     | 91.11   | 0.00  | 32.50 |
| 100%                    | 63.13   | 0.00  | 31.78 |



|                       |      |            |           |         |         |
|-----------------------|------|------------|-----------|---------|---------|
| Anova Table (Mustard) |      |            |           |         |         |
| Source of Variation   | D.F. | S.S.       | M.S.      | F       | P-value |
| Treatment             | 5    | 5430.9480  | 1086.1900 | 5.8376  | 0.0058  |
| Error                 | 12   | 2232.8250  | 186.0690  |         |         |
| Total                 | 17   | 7663.7730  |           |         |         |
| Anova Table (Gram)    |      |            |           |         |         |
| Source of Variation   | D.F. | S.S.       | M.S.      | F       | P-value |
| Treatment             | 5    | 11622.7740 | 2324.5550 | 82.5409 | 0.0000  |
| Error                 | 12   | 337.9500   | 28.1620   |         |         |
| Total                 | 17   | 11960.7240 |           |         |         |
| Anova Table (Wheat)   |      |            |           |         |         |
| Source of Variation   | D.F. | S.S.       | M.S.      | F       | P-value |
| Treatment             | 5    | 938.8560   | 187.7710  | 1.5276  | 0.2532  |
| Error                 | 12   | 1475.0260  | 28.1620   |         |         |
| Total                 | 17   | 2413.8820  |           |         |         |

**Table 7: Effects of Fertilizer Effluents on Total Chl (mg/100 fresh wt) of Mustard, Gram, and Wheat**

| Effluents Concentration | Mustard | Gram  | Wheat |
|-------------------------|---------|-------|-------|
| Control                 | 168.19  | 98.47 | 86.22 |
| 20%                     | 150.80  | 69.72 | 84.44 |
| 40%                     | 135.27  | 45.61 | 75.79 |
| 60%                     | 132.41  | 41.17 | 67.69 |
| 80%                     | 124.56  | 0.00  | 64.91 |
| 100%                    | 87.52   | 0.00  | 46.73 |

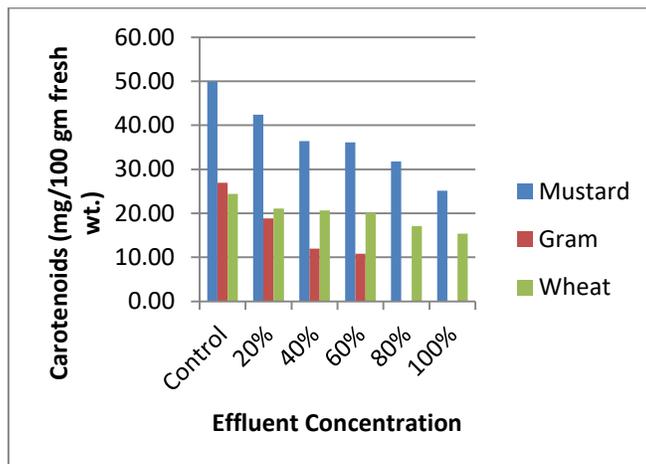


|                       |      |            |           |         |         |
|-----------------------|------|------------|-----------|---------|---------|
| Anova Table (Mustard) |      |            |           |         |         |
| Source of Variation   | D.F. | S.S.       | M.S.      | F       | P-value |
| Treatment             | 5    | 11101.4400 | 2220.2880 | 6.0855  | 0.0050  |
| Error                 | 12   | 4378.1820  | 364.8480  |         |         |
| Total                 | 17   | 15479.6220 |           |         |         |
| Anova Table (Gram)    |      |            |           |         |         |
| Source of Variation   | D.F. | S.S.       | M.S.      | F       | P-value |
| Treatment             | 5    | 22294.8010 | 4498.9600 | 64.4101 | 0.0000  |
| Error                 | 12   | 838.1840   | 69.8490   |         |         |
| Total                 | 17   | 23132.9850 |           |         |         |
| Anova Table (Wheat)   |      |            |           |         |         |
| Source of Variation   | D.F. | S.S.       | M.S.      | F       | P-value |

|           |    |           |          |        |        |
|-----------|----|-----------|----------|--------|--------|
| Treatment | 5  | 3216.0130 | 643.2030 | 1.6661 | 0.2171 |
| Error     | 12 | 4632.6850 | 386.0570 |        |        |
| Total     | 17 | 7848.6980 |          |        |        |

Table 8: Effects of Fertilizer Effluents on Carotenoids (mg/100 fresh wt) of Mustard, Gram, and Wheat

| Effluents Concentration | Mustard | Gram  | Wheat |
|-------------------------|---------|-------|-------|
| Control                 | 49.89   | 26.91 | 24.42 |
| 20%                     | 42.38   | 18.86 | 21.09 |
| 40%                     | 36.43   | 12.00 | 20.62 |
| 60%                     | 36.12   | 10.83 | 20.12 |
| 80%                     | 31.76   | 0.00  | 17.14 |
| 100%                    | 25.11   | 0.00  | 15.38 |



| Anova Table (Mustard) |      |           |          |         |         |
|-----------------------|------|-----------|----------|---------|---------|
| Source of Variation   | D.F. | S.S.      | M.S.     | F       | P-value |
| Treatment             | 5    | 1095.2870 | 219.0570 | 8.5604  | 0.0012  |
| Error                 | 12   | 307.0750  | 25.5900  |         |         |
| Total                 | 17   | 1402.3620 |          |         |         |
| Anova Table (Gram)    |      |           |          |         |         |
| Source of Variation   | D.F. | S.S.      | M.S.     | F       | P-value |
| Treatment             | 5    | 1671.3340 | 334.2670 | 43.2979 | 0.0000  |
| Error                 | 12   | 92.6420   | 7.7200   |         |         |
| Total                 | 17   | 1763.9760 |          |         |         |
| Anova Table (Wheat)   |      |           |          |         |         |
| Source of Variation   | D.F. | S.S.      | M.S.     | F       | P-value |
| Treatment             | 5    | 151.0770  | 30.2150  | 1.7375  | 0.2006  |
| Error                 | 12   | 208.6770  | 17.3900  |         |         |
| Total                 | 17   | 359.7540  |          |         |         |

## V. DISCUSSION

Perusal of table -1 reveals that the effluents from National Fertilizer Limited have higher values of pH, Alkalinity, Magnesium, Calcium, Ammonical nitrogen, Nitrate nitrogen, Nitrates and Total dissolved solids. Inhibition of seed germination occurs at higher levels of total solids due to presence of excess amount of ammonia in effluent. This causes depletion of acids from the TCA

cycle. This reduces respiration rate cumulating in reduction in germination [37]. This happens due to contaminants being absorbed by seed when soaked in the different concentrations of effluent before germination [38]. The effluent used in the present study had basic pH in the range of 8.3 to 9.5. Consequently, higher concentrations show reduced growth and germination percentage. Total Dissolved Solids (TDS) (more than 1000mg/l) are not permissible for irrigation as per Indian Standard, 1982. Higher TDS causes high osmotic pressure of soil solution. It may cause rapid deterioration of soil properties like irregular flow dynamics of salt, storage and distribution of nutrients and water uptake by plant roots. There is possibility of saline soil turning into sodic (alkaline) soil under higher concentrations of effluent [5]. Soil productivity decreases due to reduced nutrient availability and poor plant growth [39]. TDS in the effluents in our study were found in range of 88-1428 mg/l. The percentage germination and seedling growth observed in our study is also low. This is in line with earlier observations [39-40]. Higher concentrations of effluent and suspended solids interfere with physical condition of soil. High amount of suspended solids have a tendency to clog sprinkler nozzles and soil pores leading to anaerobic condition in root zone [40].

At lower concentrations the germination and growth parameters were high and subsequently higher concentrations showed minimum growth rate and germination rate. Inhibition of seed germination occurs at higher levels of total solid due to excess amount of the salinity and conductivity of the effluent preventing the seed germination [38]. In the present study, percentage of seed germination showed drastic variation with respect to different concentration of the effluent (table-2 and figure-1). Effluent enhances the growth of seedling in control condition but higher concentrations of effluent inhibit the growth of seedling as well as the percentage of germination. Comparative minimum germination in the selected three crop plants at higher concentration was observed in gram, mustard and wheat in increasing order.

As per our study, observation on seedling growth in terms of radical length, hypocotyl length, Chl-a, Chl b, total Chlorophyll and carotenoids (table-3-8 and figure 2-7) indicate that effluents exerted stress on seedling growth. The inhibitory effect was more on the hypocotyl growth rather than that of radical on a comparative basis. Inhibition of seedling growth was more pronounced in gram than in mustard and wheat. In gram and mustard, shoot length is negatively affected in comparison to root length while in wheat the reverse was observed. Similar results have been expressed by Dayama [41]. Reduction in growth of seedlings in industrial waste appears to be due to temporary deficiency of oxygen [42] and also due to very high salt Content of waste water [43]

Toxic effect of the fertilizer factory effluent seems to be due to the excess amounts of both total nitrogen and ammonical nitrogen present in the effluents. Early growth of seedling at higher concentration of the effluents is observed in the present study. The significant fall in the chlorophyll content under the higher percentage of effluent concentration might have been due to

inhibitory effect of toxicants of effluent on chlorophyll synthesis. Similar opinion has been expressed by earlier researchers as well [44-48].

## VI. CONCLUSIONS

In this study, we observed that the effluent enhances growth of seedling in control condition but higher concentration of effluent inhibit growth of seedling as well as percentage germination. Comparative minimum germination in the three selected crop plants at higher concentration was observed in gram, mustard, and wheat in increasing order. In seedling growth, the inhibitory effect was more prominent on the radical growth rather than that of hypocotyl. On a comparative basis the inhibition of seedling growth was more pronounced in gram followed by mustard and wheat.

The effluent caused marked decrease in pigment concentration of the seedlings. Further, the loss of chl-a, chl-b, total chlorophyll and carotenoids was negatively correlated with concentration of effluents. Increasing concentration of effluents might be destabilizing chloroplasts and proteins. This drastically affects the productivity of the crop plant. The mechanism involved in reduced germination, delayed germination and reduction in seedling growth of crops in relation to effluent treatment may be associated with the activity of several enzymes. Our findings lead to the conclusion that NFL effluent at higher concentrations cause inhibitory effects on germination, seedling growth and pigment concentration in all the three crop plants. However, lower concentrations were not very harmful. Behaviour of gram seeds at 80% and 100% effluent concentration was very interesting as the seeds did not germinate even after repeated attempts. This needs to be investigated further.

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