Journal of Experimental Agriculture International

Volume 45, Issue 2, Page 1-9, 2023; Article no.JEAI.96260
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Assay on the Impact of Vegetable Oil Mill Effluent on Seed Germination and Seedling Growth of *Brassica compestris* L. and *Oryza sativa* L.

Durga Lal Regar [a#], Pragya Dadhich [b†] and Poonam Jaiswal [b‡*]

[a] *Department of Botany, Government College, Rawatbhata, India.*
[b] *Department of Botany, Janki Devi Bajaj Government Girls College, Kota, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2023/v45i22100

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/96260

Original Research Article

Received: 11/11/2022
Accepted: 15/01/2023
Published: 04/02/2023

ABSTRACT

Industries of any country are one of the key determinants of its economic wealth. Industries not only utilize a huge amount of water but also cause soil and water pollution by disposing of untreated industrial effluents in water bodies and agricultural land. The study aimed to test the impact of mustard oil effluent on seed germination and seedling growth of *Brassica compestris* L. and *Oryza sativa* L. and to evaluate the scope of industrial effluent as irrigation water. Different parameters like germination percentage, germination index, germination rate, and mean germination time were evaluated with different concentrations of effluent to analyze the impact

[#] *Assistant Professor;*
[†] *Research Scholar;*
[‡] *Associate Professor;*
**Corresponding author: E-mail: poonamjaisjdbkota@gmail.com, poonamjaiskota@gmail.com;*

effluent had on plant growth. The results of the study show that industrial effluents can be used for irrigation only after appropriate dilution, increasing the concentration of effluent in irrigation water can lead to a reduction in macro and micronutrients concentration as well as heavy metal accumulation which results in the inhibition of seed germination. Thus, careful monitoring of the effects of any industrial effluent on any particular crop is a must before its application as the response of crops may vary with single effluent also.

Keywords: Industrial effluents; seed germination; seedling growth.

1. INTRODUCTION

Industrialization is an important indicator of the economic wealth of any country. But on other hand give rise to environmental pollution resulting in deteriorated soil and water quality, global warming, climate change, etc. Most industries utilize a huge amount of water and in turn, produce a considerable amount of effluents containing different organic and inorganic materials with toxic trace elements. An assessment of disposal of these effluents shows that only 60% of the total effluents disposed of are treated before disposal [1] and the rest is discharged directly into the nearby water body or the soil itself. Heavy metals and other toxins present in these effluents are a serious threat to the ecosystems [2]. Discharge of industrial effluents without proper treatment can alter the physico-chemical properties of the receiving body by increasing or decreasing water pH, increase in temperature, change in Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), heavy metals, and toxic chemical contamination. Such polluted water affects aquatic life and causes severe diseases in human beings when consumed [3], and when this water is used for irrigation causes infectious diseases in animals and humans who consume these effluent irrigated crops [4].

In agriculture-based countries like India, agro-based industries are major pillars of rural and socio-economic development and are considered to cause low pollution. In arid and semi-arid parts of the world, the use of rural and urban wastewater in agriculture is a century-old practice, due to their easy availability even in densely populated areas [5]; but for quite some time due to scarcity of clean water, some farmers started to use industrial wastewater for irrigation [6]. This practice not only compensates country's shortage for irrigation water but also prevent the adverse effect of these effluents on environment [7]. Even in non- arid regions of the world water demand is constantly increasing, which has raised the need to use wastewater as a source of water supply [8]. Around 10% of the total irrigated land utilizes untreated or partially treated wastewater globally [9], and at least 10% of the population is believed to consume wastewater-irrigated foods [10,11].

Using wastewater for irrigation can be beneficial or detrimental depending on the geographic region and type of wastewater used and their effect on various crops including vegetables [12]. There are many reports suggesting effluent irrigation as a potential alternative to freshwater irrigation as it not only reduces the limitation of water resources [13]; but also leads to the development of root system, increase the biological activity of soil [14], increase soil fertility and permeability [15], increase soil nutrients and enhance soil properties [16] and increase in the water-holding capacity [17] at a lower cost compared to water [18]. But on the other hand, the application of effluent as irrigation water can be detrimental as well as it contains toxic substances which may lead to soil pollution. Heavy metals like cadmium (Cd), nickel (Ni), lead (Pb), and chromium (Cr) are present in high concentrations in many untreated or contaminated sewage and industrial effluents [19]. Many heavy metals like iron, molybdenum, manganese, zinc, copper, magnesium, copper, selenium, and nickel have a major role in the growth and development of plants but beyond a certain level, these are also toxic [20]. If soil contaminated with these heavy metals is used for the production of crops, these can easily enter the food chain [21]. These accumulated heavy metals and macronutrients, micronutrients, from using untreated wastewater in agriculture can disrupt the uptake of mineral nutrients by plants, inhibit photosynthesis, reduce enzyme activity, interfere with physiological processes, damage cell membranes, limit biosynthesis of metabolites, and consequently decrease plant growth and yield [22,23].

The present study was conducted to study the effect of vegetable oil mill effluent on germination and seedling growth of 2 plant species (*Brassica* *compestris* L. and *Oryza sativa* L.) and to evaluate the scope of industrial effluent as irrigation water. The study was conducted in the Bundi district in India where two vegetable oil mills (Bunge India Private Limited and Adani Wilmer Limited) are working for the last 20-25 years. Mustard and Paddy are the two crops that are main crops in the study area.

2. MATERIAL AND METHODS

2.1 The Experimental Site

The effluent was collected from oil mills (Bundi, Rajasthan) and stored at 4°C to preserve the physico-chemical properties of the effluent.

2.2 The Biological Material

Certified seeds of *Brassica compestris* L. variety Pusa Bold and *Oryza sativa* L. variety Kaveri 888 were collected from the Department of Agriculture, Bundi District, Rajasthan, India. Seeds that are healthy and uniform in shape and size were selected, sterilized with Mercuric Chloride ($HgCl_2$), and then washed thoroughly twice to remove traces of $HgCl_2$. These seeds were then soaked in distilled water for 2-3 hours.

2.3 The Experimental Variants

Two sets of experiments were then settled; one for mustard seeds and the other for rice seeds. Effluent was then diluted to 0% oil mill effluent (OME) as control, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100% (not diluted). 10-10 seeds of mustard and paddy were then placed equidistantly in pre-labelled Petri dishes containing filter paper soaked in water. After this 5mL of each prepared concentration of OME was added to both separate sets of treatment and then left in dark for 48 hours for germination. Three replicates of all the treatments including the control were prepared and maintained.

2.4 The Parameters Determined

Since, the first physiological process of plant growth is seed germination, growth parameters like seed germination, germination percentage, and seedling growth are considered as criteria to assess the degree of impact on plant growth caused by pollution. The final germination percentage (FGP %) was recorded on the 10th day [24], and seedling length was taken and recorded on the 15th day of seedlings growth (10th day of seed germination was taken as 0 days for seedling growth). The values of germination percentage, germination index, germination rate, and mean germination time [25] were observed for each set of treatments.

a). Final Germination percentage(FGP) % = $\frac{number\ of\ seeds\ germinated}{Total\ number\ of\ seeds\ sown}$ ×100

b). Germination index (GI) = $\frac{No.of\ germinated\ seeds}{Days\ of\ first\ count}$ ..+$\frac{No.of\ germinated\ seeds}{Days\ of\ final\ count}$

c). Germination rate (GR) = $\frac{X1}{Y1} + \frac{X2-X1}{Y2}$ +………..+ $\frac{Xn-Xn-1}{Yn}$

Where Xn = number of germinations on the nth day
Yn = number of days from the first-day experiment

d). Mean germination time (MGT) = $\frac{\sum Dn}{\sum n}$ days
Where, n = no. of seeds that have germinated on day D
D = no. of days counted from the beginning of the experiment

Data for seedling growth were collected 15 days after 10 days of germination (the 10th day of germination was considered 0 days for seedling growth) for both *Brassica compestris* L. and *Oryza sativa* L.

3. RESULTS

Different concentrations of OME have a significant effect on germination percentage (GP), germination index (GI), germination rate (GR), and mean germination time (MGT) (Table 1). In the case of treatment 1 (Mustard seeds), maximum germination was found at 0% (control) and 10% OME which gradually decrease towards 100% OME. The same trend is observed in the case of GI and GR. But in the case of MGT a reverse trend is observed i.e., it increases with increasing concentration of OME.

In the case of treatment 2 (Paddy seeds); data obtained is quite a similar trend i.e., GP, GI, and GR are maximum at 0% OME or control while on the other hand, MGT increase with increasing concentration of OME.

Table 1. Parameters related to the germination of *Brassica compestris* L. and *Oryza sativa* L. seeds with mustard oil mill effluent (OME) (Data showing ±SE) N=3

OME Conc. (%)	Final germination percentage (FGP)%		Germination Index (GI)		Germination rate (GR)		Mean germination time (MGT) days	
	***Oryza sativa* L.**	***Brassica compestris* L.**	***Oryza sativa* L.**	***Brassica compestris* L.**	***Oryza sativa* L.**	***Brassica compestris* L.**	***Oryza sativa* L.**	***Brassica compestris* L.**
0	100	100	6.39±0.63	8.75±0.62	1.75±0.01	2.18±0.63	1	1
10	90±2.98	100	4.54±1.44	8.61±0.02	1.40±0.25	2.15±0.12	1.11±0.05	1
20	60±3.66	80±1.09	3.59±0.96	5.82±0.31	1.02±0.06	1.48±0.06	1.67±0.12	1.25±
30	80±2.85	80±2.34	3.80±0.56	5.68±1.01	1.17±0.04	1.46±0.11	1.25±0.13	1.25
40	80±3.74	90±0.22	3.80±0.22	6±0.61	1.17±0.61	1.58±0.67	1.25±0.04	1±0.02
50	70±1.69	60±0.69	2.79±1.20	4.39±0.09	0.94±0.02	1.1±0.22	1.43±0.05	1.67±0.04
60	60±2.68	60±1.50	2.25±1.32	4.92±0.12	0.79±0.31	1.18±0.26	1.67±0.15	1.67±0.01
70	70±5.12	50±0.56	2.66±0.98	3.71±0.62	0.93±0.01	0.93±0.06	1.43±0.21	2±0.11
80	70±3.99	50±0.68	2.90±0.87	3.77±0.33	0.96±0.08	0.94±0.02	1.43±0.06	2±0.02
90	30±2.01	40±1.62	1.77±0.77	3.07±0.69	0.48±0.03	0.76±0.13	3.33±0.11	2.5±0.03
100	40±0.89	50±1.01	2.11±1.05	3.36±0.51	0.60±0.03	0.78±0.60	2.5±0.15	2.5±0.05

Table 2. Seedling length (cm) of *Brassica compestris* L. and *Oryza sativa* L. after 15, 30, 45, and 60 days with mustard oil mill effluent (OME) treatment (Data shown ±SE) N=3

Effluent conc. %	15 Days Seedling		30 Days Seedling		45 Days Seedling		60 Days Seedling	
	***Oryza sativa* L.**	***Brassica compestris* L.**	***Oryza sativa* L.**	***Brassica compestris* L.**	***Oryza sativa* L.**	***Brassica compestris* L.**	***Oryza sativa* L.**	***Brassica compestris* L.**
0	18.4±3.08	6.5±1.05	29.4±3.22	10.8±2.37	56±2.98	57±3.21	67.8±3.64	61.8±3.33
10	18.2±3.69	6.5±0.59	29.1±2.69	10.7±1.59	56±3.68	57±3.11	67.2±5.37	61.2±2.15
20	18.1±2.99	5.5±1.32	28.4±1.54	10.4±2.54	56±2.69	55.7±1.89	66.2±3.99	60.4±1.25
30	17.9±0.97	5.2±0.99	27.5±1.62	9.9±2.33	49.2±3.54	54.2±2.14	64.8±4.67	59.9±1.98
40	17.8±1.58	4.9±1.01	27±1.28	9.2±0.62	48.3±1.09	53±0.88	63.1±2.11	58.8±0.59
50	15.2±2.55	4.9±2.05	26.5±3.66	8.7±0.54	48±2.67	52.4±0.69	61.2±6.21	58.2±1.05
60	14.7±3.11	4.8±0.06	26.1±1.89	8.5±1.08	46.6±2.14	50.8±2.10	58.3±3.27	56.7±1.66
70	14.5±2.14	4.0±0.59	24.8±2.05	8.7±0.78	45.4±1.68	50.1±0.99	56.7±2.17	55±1.87
80	14±2.58	3.7±0.32	24.5±1.57	8.2±1.12	45.4±3.68	49.4±1.57	55.4±2.91	54.3±2.36
90	12.9±2.09	3.6±0.56	24.1±1.69	7.7±0.67	41.3±2.18	48.2±1.33	52.5±3.64	54.1±2.55
100	12.5±0.08	3.6±0.24	24±3.46	5.7±0.64	40.1±2.10	48.2±2.11	50.5±5.77	52.5±3.11

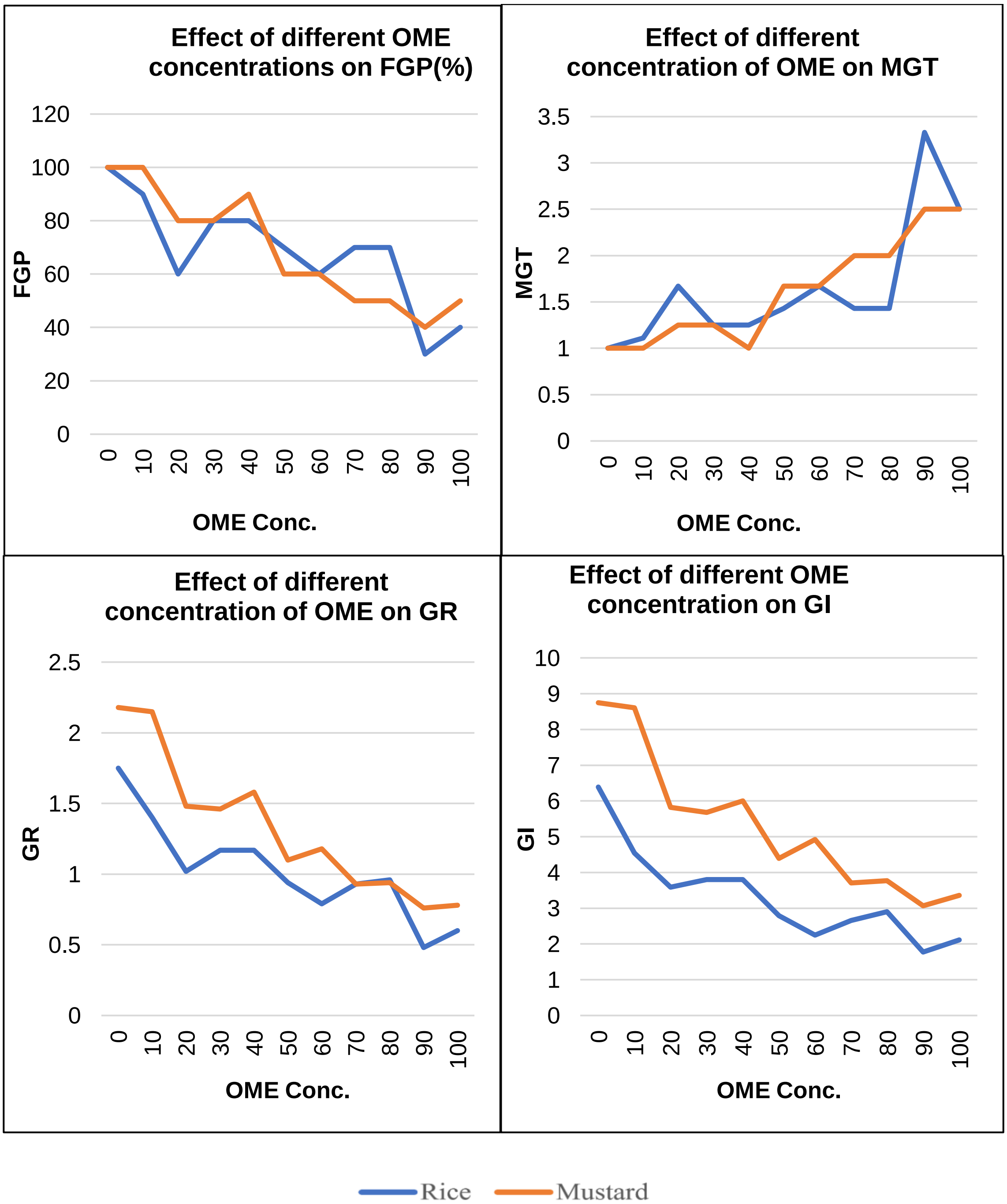

Fig. 1. Effect of OME concentrations on different germination parameters

Results on seedling growth (Fig. 2) show that in both cases i.e. *Brassica* and *Oryza* early seedling growth (15 days or 30 days) was more negatively affected by OME; afterward, seedlings develop tolerance to OME.

4. DISCUSSION

Industrialization is an inevitable cause of pollution, by dumping untreated effluents affects both water and soil quality [26]. In past, some poor countries used land disposals of municipal, agricultural, and industrial wastes as irrigation water as it is a source of nutrients and organic matter, due to the high cost of chemical fertilizers [27]. Irrigation with wastewater has multifold benefits as it reduces the cost of irrigation, lowers the application of chemical fertilizers, conserves water, and minimizes pollution loads

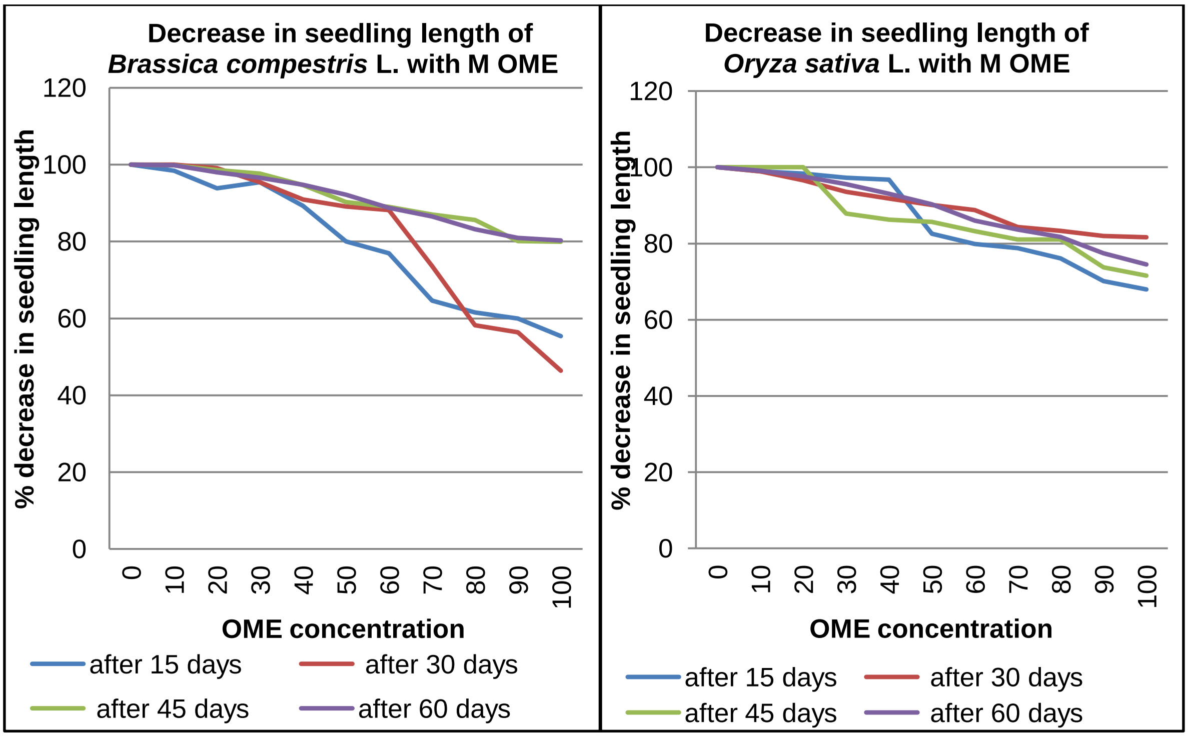

Fig. 2. Percentage decrease in seedling length (cm) of *Brassica compestris* L. and *Oryza sativa* L. after 15, 30, 45 and 60 days of mustard OME treatment

of the water bodies where these effluents have to be disposed of [28,29]. Most of the crops give higher yields when irrigated with wastewater [30].

The edible seed oil industry is known to produce resources, water, energy, and wastes in large amounts; and it has been observed in many cases that the wastes and by-products are not utilized to their full potential [31]. Mostly biodegradable organic substances are present in wastewater from oil refining units [32]. Being a by-product of agricultural produce, waste from the edible oil industry has great potential for further valorization and water reuse.

The present study found an increase in mean germination time with increasing effluent concentration. There are many possible explanations for this higher salt concentration in polluted water which delays germination [33]; the excess amount of ammonia causes depletion of the tricarboxylic acid cycle, reducing the respiration rate of seeds which ultimately leads to low seed germination [34]. High level of dissolved solids in the effluent results in increases the salinity and conductivity of the absorbed solutes by seed causing inhibition of seed germination [35]. Higher concentration of effluent causes change in soil macro and micronutrients level in soil and found to be useful for irrigation at very low concentrations [36]. Besides these excess of total nitrogen, phosphate, potassium, sulphate, chloride present in the effluent causes inhibitory effect on seed germination and seedling growth by reducing water absorption and affecting other metabolic processes in the plant [37].

Seed germination percentage also reduces with increasing effluent concentration. It was reported in a study that the lowest concentration of heavy metals in industrial effluents has the least harmful effect on germination whereas at higher concentration strength of germination is significantly reduced [38]. Other than this; high total dissolved solids (TDS) and total suspended solids (TSS) can also change the osmotic relation between seed and water, which causes retardation of seed germination by increased salinity. The rate of germination as well as the seed germination index shows a decreasing trend with increasing OME concentration.

It is reported in the present study that the length of seedling shows a decreasing trend with increasing OME concentration. Similar results were obtained by Banzai and Achakazai [39] who reported a decrease in seedling growth with increasing OME concentration. Many authors reported that metal interference with cell division and cell elongation is the key cause of heavy metal-mediated root inhibition [40,41].

At lower concentrations of OME, seed germination, as well as seedling growth, are not affected, but a higher concentration of OME is known to inhibit both. Higher electrical conductivity and excessive inorganic salts are possibly the cause of this. However, effluent quality obtained from the same industry can also vary based on physical, chemical, and biological methods used for oil extraction and wastewater treatment, but untreated effluent is always more toxic than treated effluent. Results of the present study prove that at lower concentrations of mustard oil mill effluent, all parameters taken under study (GP, GR, GI, MGT) gives favourable results. A low concentration of effluents not only favours seed germination but promotes the overall growth of the plant. These findings suggest that higher effluent concentrations were found to negatively affect plant growth, but diluted effluent favoured seedling growth [42, 43].

The increasing demand for water for the agriculture sector and diminishing availability have made use of industrial effluents after proper treatment, an attractive alternative for irrigation. The use of treated effluent not only sorts the problem of water shortage but can prove beneficial to crop plants because of the nutrients present in it [44,45].

5. CONCLUSION

Results of the present study revealed that the response of *Oryza sativa* L. to mustard OME is comparatively more inhibitory way than *Brassica compestris* L. This concludes that different crop species have varying tolerance towards industrial OME, and that vegetable oil effluent can be used as potential irrigation water only after careful monitoring of crop species' tolerance towards that particular effluent. Results have also shown that OME can be used for irrigation only after appropriate dilution; increasing the concentration of OME in irrigation water can lead to a reduction in macro and micronutrient concentration as well as heavy metal accumulation which results in the inhibition of seed germination. Thus, proper treatment of industrial effluent as well as proper assessment of its effects on particular crop plants is a must before its application as an irrigation alternative.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kaur R, Wani SP, Singh AK, Lal K. Wastewater production, treatment, and use in India. The national report presented at the 2nd regional workshop on the safe use of wastewater in agriculture, New Delhi, India; May 16-18, 2012.
2. Amathussalam A, Abusbacker MN, Jayabal NJ. Physico-chemical parameters and concentration of heavy metals in the sugar industry. Ind. Poll. Con., 2002;1(3):118- 119.
3. Morrison G, Fatoki OS, Persson L, Ekberg A. Assessment of the impact of point source pollution from the Keiskammahoek Sewage Treatment Plant on the Keiskamma River-pH, electrical conductivity, oxygen- demanding substance (COD) and nutrients. Water SA. 2001;27(4): 475–480.
4. Bouwer H. Integrated water management: Emerging issues and challenges. Agricultural Water Management. 2000;45(3): 217-228.
5. Nafchi RF, Yaghoobi P, Vanani HR, Ostad-Ali-Askari K, Nouri J, Maghsoudlou B. Correction to: Eco-hydrologic stability zonation of dams and power plants using the combined models of SMCE and CEQUALW2. Appl Water Sci. 2022;12(4):55.
6. Rathore NP, Iqbal SA, Panwar KS. Role of sugar industry in Agriculture. Indian J. Appl. Biol. 2000;15:91-94.
7. Ostad-Ali-Askari K. Developing an optimal design model of furrow irrigation based on the minimum cost and maximum irrigation efciency. Appl Water Sci. 2022;12(7):144.
8. Razmi R, Sotoudeh F, Ghane M, Ostad-Ali-Askari. Temporal–spatial analysis of drought and wet periods: case study of a wet region in Northwestern Iran (East Azerbaijan West Azerbaijan Ardebil and Zanjan provinces). Appl Water Sci. 2022;12(11): 251.
9. Winpenny J, Heinz I, Koo-Oshima S, Salgot M, Collado J, Hérnandez F, et al.

Reuse of water in agriculture: benefits for everyone;FAO: Rome, Italy. 2013;124.
10. WHO. Guidelines for the Safe use of wastewater, excreta and grey water. Policy and regulatory aspects, 2006;Vol. 1 & II, World Health Organisation, Geneva.
11. Hamilton AJ, Stagnitti F, Xiong XZ, Kreidl SL, Benke KK, Maher P. Wastewater irrigation: the state of play. Vadose Zone J. 2007;6 (4): 823–840.
12. Ramana S, Biswas AK, Kundu S, Saha JK, Yadava RBR. Effect of distillery effluent on seed germination in some vegetable crops, Bioresource Technology. 2002;82(3):273-275.
13. Talebmorad H, Koupai JA, Eslamian S, Mousavi SF, Akhavan S, Askari KOA, Singh VP. Evaluation of the impact of climate change on reference crop evapotranspiration in Hamedan-Bahar plain. Int J Hydrol Sci Tech. 2021;11(3):333.
14. Hassanoghli A, Liaghat A, Mirabzadeh M. Investigation of soil saturated hydraulic conductivity changes via irrigation by raw and treated domestic wastewaters. Journal of Agricultural Science. 2005;4:99–109.
15. Abedi-Koupai J, Mostafazadeh-Fard B, Afyuni M, Bagheri MR. Effect of treated wastewater on soil chemical and physical properties in an arid region. Plant Soil and Environment. 2006;52(8), 335.
16. Rezapour S, Samadi A, Khodaverdiloo H. Impact of long-term wastewater irrigation on variability of soil attributes along a landscape in semi-arid region of Iran Environ. Environmental Earth Sciences. 2012;67(6): 1713–1723.
17. Saber MSM. Prolonged effect of land disposal of human wastes on soil conditions. Water Science & Technology. 1986;18:371–374.
18. Ostad-Ali-Askar K, Su R, Liu L. Water resources and climate change. J Water Climate Change. 2018;9(2):239–239.
19. Narwal RP, Antil RS, Gupta APJ. Soil Pollution through industrial effluents and its management. J Soil Contamination. 1992;1(3): 265-272.
20. Edday NO, Odoemelan SA, Mbaba A. Elemental composition of soils in some dumpsites, Electronically, Journal of Environmental Agriculture and Food Chemistry. 2006;5(4):1399-1465.
21. Principi P, Villa F, Bernasconi M, Zanardini E. Metal toxicity in municipal wastewater activated sludge investigated by multivariate analysis and in situ hybridization. Water Research. 2006;40: 99-106.
22. Kochian L, Piñeros M, Hoekenga O. The physiology, genetics and molecular biology of plant aluminum resistance and toxicity. Plant and Soil. 2004;274*,* 175-195.
23. Cole JC, Smith MW, Penn CJ, Cheery BS, Conaghan KJ. Nitrogen, phosphorus, calcium, and magnesium applied individually or as a slow-release or controlled-release fertilizer increase growth and yield and affect macronutrient and micronutrient concentration and content of field-grown tomato plants. Sci. Hortic. 2016;21(1): 420–430.
24. Sundaramoorthy P, Chidambaram ALA, Sankar Ganesh K, Rajesh M. Growth response on paddy (*Oryza sativa* L.) for sugar mill effluent irrigation. Pollut Res. 2006;25(4):749–752.
25. Ellis RH, Roberts EH. The quantification of aging and survival in orthodox seeds, Seed Science and Technology. 1981;9:373-409.
26. Quazilbash AA, Farayal R, Naqui KB. Efficacy of indigenous *Bacillus* species in the removal of chromium from industrial effluent. Biotechnology. 2006;5(1):12-20.
27. Younas M, Shahzad F. Assessment of Cd, Ni, Cu and Pb pollution in Lahore, Pak. J. Environ. 1998;24:761-766.
28. Hylander LD, Kietliriska A, Renman G, Simon G. Phosphorus retention in filter materials for wastewater treatment and its subsequent suitability for plant production. Bioresource Technology, 2006;9(7): 914-921.
29. Thapliyal A, Vasudevan P, Dastidar MG. Domestic wastewater for fertigation: A solution for water recycling and irrigation. Proceedings of Micropollutant Ecohazard. 6th IWA/GRA Specialized conference on assessment and control of micro pollutants/ hazardous substances in water. 8-10th June, San Francisco, USA. 2009;317.
30. Ezhilvannan D, Sharavanan PS, and Vijayaragavan M. Effect of sugar mill effluent on changes of growth and amino acid and protein contents of maize (*Zea mays* L.) plants. Journal of Ecobiotechnology. 2011;3(7):26–29.
31. Welz PJ, Le Roes-Hill M, Swartz CD. *NATSURV 6:* Water and Wastewater

Management in the Edible Oil Industry (Edition 2) WRC TT. 2017;702/16.
32. Aslan S, Alyüz B, Bozkurt Z, and Bakaoğlu M. Characterization and Biological Treatability of Edible Oil Wastewaters, Polish J. of Environ. Stud. 2009;18(4):533–538.
33. Hoorn JW van. Development of soil salinity during germination and early seedling growth and its effect on several crops, Agricultural Water Management. 1991;20(1):17-28. DOI:https://doi.org/10.1016/0378-3774(91)90032-E
34. Bradford K, Côme D, Corbineau F. Quantifying the oxygen sensitivity of seed germination using a population-based threshold model. Seed Science Research. 2007;17(1):33-43. DOI:10.1017/S0960258507657389
35. Singh PP, Manish M, Singh J. Impact of fertilizer factory effluent on seed germination, seedling growth and chlorophyll content of gram (*Cicer aeritenum*). J. Environ. Biol. 2006;27:153-156.
36. Regar D, Jaiswal P. Impact of vegetable oil mill effluents on soil characteristic in Bundi district, Rajasthan, India. Int. J. Eco. & Env. Sci. 2020;2(4):25-29.
37. Dutta SK, Boissya CL. Effect of paper mill effluent on the yield components of rice (*Oryza sativa* L.) Eco. Env. Conserv. 2000;6(4):123-128.
38. Peralta-Videa JR, de la Rosa G, Gonzalez JH, Gardea-Torresdey JL. Effects of the growth stage on the heavy metal tolerance of alfalfa plants, Advances in Environmental Research. 2004;8(3-4):679-685.
39. Banzai ZA, Achakzai AKK. Effect of wastewater from Quetta city on germination and seedling growth of Lettuce (*Lactuca sativa* L.). Journal of Applied Science. 2006;6:380–382.
40. Kidd P, Díez J, Martínez CM. Tolerance and bioaccumulation of heavy metals in five populations of *Cistus ladanifer* L. subsp. *ladanifer.* Plant and Soil. 2004;258(1): 189-205.
41. Rout G, Samantaray S, Das P. Differential chromium tolerance among eight mungbean cultivars grown in nutrient culture. Journal of plant Nutrition. 1997;20(4-5):473-483.
42. Ayyasamy PM, Yasodha R, Rajakumar S, Lakshmanaperumalsamy P, Rahman PK, Lee S. Impact of sugar factory effluent on the growth and biochemical characteristics of terrestrial and aquatic plants. Bull. Environ. Contam. Toxicol. 2008;81 (5):449-54.
43. Regar D, Jaiswal P. Effect of vegetable oil mill effluents on seed germination and seedling growth of *Glycine max* (L.). Eco. Env. & Cons. 2020;26(2):606-611.
44. Sahai R, Shukla N, Jabeen S, Saxena PK. Pollution effect of distillery waste on the growth behaviour of *Phaseolus radiatus* L. Environmental Pollution Series A, Ecological and Biological. 1985;37:245-253.
45. Mishra RN, Behera PK. The effect of paper industry effluent on growth, pigment carbohydrate and proteins of rice seedling. Environ Pollut. 1991;72 159-167.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/96260