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Impact of Industrial Effluents in Seed Invigouration: A Review

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Abstract: Use of industrial effluents for irrigation purposes is a highly warranted utility of water pollutants proposition. The objective of using waste water for irrigating crop plants is of two fold. The first and foremost of this is the safe disposal of the effluents, which may otherwise have adverse effects on the environment and human health. The other objective is to recycle it as irrigation water, as compost for its possible fertilizer value. The literatures relating the influence of industrial waste water on seed and seedling quality characters irrespective of crops are reviewed hereunder.

Key words: Waste water, agricultural crops, horticultural crops

INTRODUCTION

Effect on agricultural crops

Rice: Behera and Misra (1982) analysed the effect of distillery effluents on growth and development of rice seedlings and reported that the germination per cent, number of roots, shoot and root length, fresh and dry weight of the seedlings showed a reverse relationship with effluent concentration.

Sahai *et al.* (1983) reported that rice seeds treated with different concentration of spentwash (0, 5, 10, 25, 50, 75 and 100%). At higher concentration (25% and above) both the speed of germination and seedling growth were retarded. At 5% concentration overall growth of seedling was better than in control and suggested that by diluting the effluent to 5% the effluent can be used as a substitute for chemical fertilizes. The chlorophyll a and b decreased with increase in the effluent concentration. The carotenoid content continued to increase up to 5% effluent concentration.

Dixit *et al.* (1986) presoaked the rice seeds in varying concentrations of cardboard factory effluent for 15 and 24 h and germinated in distilled water while another set was germinated under continuous application of various concentrations of effluent. They observed an inhibition in germination with increasing the concentrations of effluent as well as increasing the pre-soaking period. The seeds germinated in continuous application of effluent exhibited a maximum of 62% germination in 25% concentration and a minimum of 8% germination in pure effluent (100% concentration). The seeds presoaked for 15 h showed better germination than those presoaked for 24 h. The germination capacity decreased with increase in concentration of effluent as well as increasing the pre-soaking period. The seeds, which were supplied with 25% of effluent continuously, showed better growth as compare to control. When seeds were pre-soaked in 25% and 100% effluent showed higher cation concentration that had adverse effect on seed germination and seedling quality characters. However, when the concentration range is between 2.5 to 5.0%, no significant deviation in the germination per centage was noted but at 50% effluent only 15% of rice seeds germinated. With further increase in effluent concentration delay in primary root emergence was noticed.

Rajaram and Janardhanam (1988) studied the effect of distillery effluent on seed germination and early seedling growth of rice and reported that the processed effluents were rich in inorganic constituents like ammoniacal nitrogen, chemicals and traces of heavy metals and these markedly suppressed the germination per cent and early growth of the seedling as the concentration of the effluent increased.

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Karunyal *et al.* (1994) too studied the effects of tannery effluent at different concentrations (25, 50, 75 and 100%) on seed germination of *Oryza sativa* and found that the germination was inhibited by 25 and 50% effluent and completely suppressed by 75 and 100% effluent. Even the chlorophyll and protein contents of plants were found to decrease with the effluent concentration of 75 and 100%.

Application of spentwash with 50 times dilution in rice (CO43) resulted in normal yield (Rajannan *et al.*, 1998). The maximum grain yield was recorded in rice variety ADT 42 due to 75 times diluted distillery spentwash treatments which was on par with 100 times diluted spentwash application (Chinnusamy *et al.*, 2001).

Rani and Alikhan (2007) studied the effect of treated distillery effluent on two cultivars of *Oryza sativa* L. Cv. Saka-4 and Pusa 44 after diluted with tap water viz., 100, 50 and 25% in petriplates over the control. It was observed that root length, shoot length fresh weight root and shoot, dry weight of root and shoot germination relative index, vigour index, emergence index and chlorophyll content were higher in 25% than 50% over control. Singh *et al.* (2007) observed that the per centage germination and seedling vigour of rice and wheat decreased significantly with an increase in spentwash concentration.

Wheat: Mishra and Bera (1995) soaked the cv. Kalyansona after surface sterilization in different effluent concentrations from crude tannery effluent and revealed that up to 5% concentration, germination process had stimulating effect, while further increase in concentration of the effluent, a corresponding decrease in germination per cent occurred due to depletion of dissolved oxygen, both by chemical and biological oxidation of sulphur and organic compounds. They also reported that absorption of higher dissolved solids by the seed also could have affected the germination.

Aliotta *et al.* (2002) revealed that olive Mill waste water had phytotoxic influence on wheat cv.Ofonto due to the polyphenoles and other unidentified substances. Kaushik *et al.* (2005) conducted laboratory experiments to study the effect of textile effluents at different concentrations in the range of 0-100% (untreated and treated) on seed germination (%), delay index (DI), plant shoot and root length, plant biomass, chlorophyll content and carotenoid of three different cultivars of wheat. The textile effluent did not show any inhibitory effect on seed germination and other plant characters at low concentration (6.25%). Seeds germinated in undiluted effluents did not survive for longer period. Based on the tolerance to textile effluent, the wheat cultivars have been arranged in the following order: PBW-343 < PBW-373 < WH-147. It has also been concluded that effect of the textile effluent is cultivar specific and due care should be taken before using the textile effluent for irrigation purpose.

Sorghum: Positive influence of distillery waste water on sorghum yield has also been reported by Zalawadia and Raman (1994). The shoot and the root length and the number of lateral roots formed in the case of sorghum attained maximum values when treated with 2.5% distillery spentwash (Rajaram and Janardhanam, 1988). Kalaiselvi *et al.* (2009) also reported that the distillery spentwash did not show any inhibitory effect on seed germination at low concentration. The spentwash at a higher concentration reduced the seed germination. But up to 10% concentration the distillery spentwash markedly improved the seed germination and seedling growth in White sorghum (APK 1) and Red sorghum (Namakkal local).

Pearl millet: Vijayakumari (2003) reported that soap factory effluent was toxic to seed germination and seedling growth of finger and pearl millet, but when the effluent was diluted to 2.5 to 5.0% it enhanced the seed germination and seedling growth.

Maize: Giovacchino *et al.* (2001) expressed that Olive Vegetable Water (OVW), the liquid by - product obtained from olive processing to extract virgin olive oil by mechanical means (pressure and centrifugation systems) and spread OVW in large quantities on soil cultivated with maize revealed that the use of large quantities of OVW (more than 10 L m^{-1}) gave a 30-40% increase in the total biomass production compared with the control. All the parameters, i.e., germination, stalk, ear and dry kernel per plot in maize were also increased by large quantities of OVW. The grain yield and biomass yield of maize was significantly higher due to spentwash application. The spentwash also increased the N, P, K, Ca, Mg and Na content in all the parts of the maize crop (Mallika, 2001).

Pandey (2004) studied the effects of effluent from an electroplating industry, on its seed germination and seedling growth in maize (cv. GK-3014) and found that the effluent sample showed high values of TSS, hardness, BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) and was contaminated with the toxic heavy metals Zn (2.32 mg L^{-1}), Ni (0.935 mg L^{-1}), Cr (0.093 mg L^{-1}) and Cd (0.013 mg L^{-1}). The effluent showed an inhibitory effect on seed germination and seedling growth. Approximately 80% seedling mortality, followed by leaf necrosis and browning of root tips, was recorded

after 15 days of growth. The severity of toxicity was reduced after the dilution of the effluent to 50%. The study suggests that the effluent should be properly treated before being discharged into the drain to avoid adverse effects on plants through irrigation.

Kalaiselvi *et al.* (2009) conducted a laboratory experiment to study the effect of different concentrations (Control, 1, 2, 3, 4, 5, 10, 15 and 20%) of distillery spentwash on seed germination, root length, shoot length and vigour index in Maize (Super 900M). Up to 10% concentration the distillery spentwash markedly improved the seed germination and seedling growth in all crops. The distillery spentwash can be used safely after proper dilution as substitute for chemical fertilizer to the crop plants.

Pulses: Augusthy and Mani (2001) conducted physico-chemical analysis of the rubber factory effluents and revealed that high amounts of total suspended and dissolved solids, sulphate, phosphate, total nitrogen were also present in significant amounts. On evaluation of seed quality responses with *Vigna radiata* found that at higher concentration (above 50%) of effluent, the seed germination per centage was retarded. Diluted effluent (up to 50%) favoured seedling growth. Seedling length and number of lateral roots were increased by low concentrations of effluent.

Srivastava and Sahai (1987) suggested that the early seedling growth of cowpea was promoted by the distillery effluent up to 10% concentration. The effluent at concentration of more than 10% suppressed the seedling growth. They expressed the nutrients and organic pollutants inhibit seedling growth by altering the osmotic relations and the distillery effluent could be used as a liquid fertilizer only for certain crops after proper dilution with water.

Karande and Ghanvat (1994) reported that the distillery effluent had significant deleterious effect on seed germination and early seedling growth in pigeon pea. Ghosh *et al.* (1999) studied the effects of 0-100% distillery on germination of peas, *Cicer arietinum* and *Phaseolus mungo*. The per centage of germination increased with up to 75% effluent in *Cicer arietinum* and peas and up to 50% effluent in *P. mungo*. The plumule and radicle growth generally increased up to 50 or 75% effluent concentration and then decreased. The root:shoot ratio decreased with increasing effluent concentration.

Singh *et al.* (2006) revealed the effect of fertilizer factory effluent on seed germination, seedling growth and chlorophyll content of gram (*Cicer aeritenum*), at different concentration of the effluent and time intervals. The effluent was alkaline in nature with strong ammonia odour. The germination per centage of seed, seedling growth and chlorophyll content which showed a gradual decline with increase in effluent concentration. Evaluation of seedlings at 21 days at 25% concentration recorded an increase in root and shoot length and chlorophyll content at 21 days. However, at higher concentrations of the effluent toxic effects were observed at 21 days. Thus the study suggested that the effluent could be used safely for *Cicer aeritenum* cultivation, after proper treatment and dilution.

The per centage germination and speed of germination index (SGI) in *Phaseolus radiatus increased* correspondingly with increase in effluent concentration up to 5% and the growth and biomass of seedlings and their pigment content up to 10% (Sahai and Neelam, 1987). The protein content in peas registered a decreasing trend with increasing concentration of spentwash (Rani and Shrivastava, 1990).

The results from a pot experiment showed that the spentwash >50 m^3 ha^{-1} was found detrimental for germination and establishment of greengram in vertisol, whereas in alfisol even at 25 $m^3 ha^{-1}$, the spent wash was found to inhibit the germination and growth of greengram. However, in vertisol the germination, growth, nutrient contents and yield of greengram were significantly improved with spentwash application at 25 m^3 ha^{-1} (Murugaragavan, 2002).

Rajaram *et al.* (1988) soaked blackgram seeds in different concentrations of distillary effluent (1, 2.5, 5.0, 10, 25, 50 and 100%) using water soaking as control. After 8 days of germination period it was noticed that effluent treatment up to 2.5% concentration, effluent treatment promoted seedling growth, but at higher concentrations, the effluent has the salinity due to the dissolved solid accumulation. At higher concentration, trace elements like zinc, hinder plant growth by binding enzyme proteins.

Rajaram and Janardhanam (1988) studied the effect of distillery effluent on seed germination and early seedling growth of soybean and cowpea by surface sterilizing with $HgCl_2$ and soaking in different concentrations (1-100%) of distillery effluent, using distilled water served as control. The result revealed that the processed effluent were rich in inorganic constituents like ammonical nitrogen, chemicals and traces of heavy metals, markedly suppressed the germination per centage and early seedling growth of soybean as the concentration of the effluent increased.

Salunke *et al.* (2007) investigated the effect of pulp and paper mill effluents (both untreated and treated) on carbohydrate metabolism in mungbean varieties K-851 and BM-4. A dose dependent increase in starch content of seedlings of both the varieties was observed. Seedlings

treated with 25% concentration of both the effluents showed increase in the activity of α-amylase. The higher concentrations of both the effluents decreased the enzyme activity.

Elayarajan (2002) reported the germination and vigour index of rice, maize, blackgram, greengram and soybean crops with 25, 50 and 75% pulp and paper mill effluent concentration was more than the normal water for irrigation. The biochemical and mineral contents were increased in blackgram applied with different concentrations (0, 5 10, 25, 75 and 100%) of sago factory effluent was observed by Sivaraman and Thamizhiniyan (2005). The highest amount of protein content was recorded at 10% effluent concentration and the lowest content was recorded at 75%. The same trend observed in paddy seedlings under tannery effluent treatment (Lakshmi and Sundaramoorthy, 2001).

Sharma and Singh (1999) evaluated the two inhreds of black gram (*Vigna mungo* L. Hepper) viz., PU-30, T-9 for their response to different concentrations of Rubber Factory effluent and city waste water (i.e., 80, 90 and 100%) and found that both the Rubber Factory effluent and city waste water showed the presence of heavy metals, copper and zinc, which were observed in maximum quantity in city waste water. Studies also revealed that irrespective of the varieties involved, city waste water showed a significant reduction in seed germination, seedling height, pollen fertility, seed fertility, mitotic index and increased chromosomal abnormalities and M [2] generation. thus proving city waste water as more efficient mutagen in nature as compared to Rubber Factory effluent. A distinct genotypic response as evidenced by M [1] and M [2] observations indicated that variety PU-30 was more sensitive than variety T-9.

Ghosh *et al.* (1999) studied the effects of 0-100% distillery on germination of peas, *Cicer arietinum* and *Phaseolus mungo*. The percentage of germination increased with up to 75% effluent in *Cicer arietinum* and peas and up to 50% effluent in *P. mungo*. The plumule and radicle growth generally increased up to 50 or 75% effluent concentration and then decreased. The root: shoot ratio decreased with increasing effluent concentration.

Oilseeds: Diluted effluent of dyeing factory, exerted a promotive effects on plant growth and biomass (Swaminathan and Vaidheeswarn, 1991) in groundnut. Sundaramoorthy *et al.* (2001) studied the effect of different concentrations (0, 1, 2.5, 5, 10, 25, 50, 75 and 100%) of fertilizer factory effluent on seed germination and seedling growth in groundnut varieties CO_2, ICG-FDRI, TMV-7 and VRI-2 in the laboratory and revealed that the per centage of germination and seedling growth increased with 1 to 10% effluent concentration treatments while 25 to 100% concentration decreased germination per centage and seedling growth. The highest and lowest germination per centages were recorded in VRI-2 and CO_2, respectively. VRI-2 control seedlings had the highest length while CO_2 the lowest seedling length. The control seedlings showed the highest fresh and dry weight than the effluent treated plants in all the varieties tested. Among the varieties studied, VRI-2 was more tolerant than the other varieties while at 5% effluent concentration favored the seedling development. Arumugam (2007) observed that pharmaceutical factory effluent at 25% dilution promoted the seed germination, seedlings growth and dry matter production in the five varieties (VRI-3, TMV-1, VRI-2, JL-24, VRI-4) of groundnut, but at higher concentrations an inhibitory effect was observed. Kalaiselvi *et al.* (2007) observed the effect of spentwash on the reduction in germination of crops with greater concentration viz., 15 and 20%. The germination study also included the evaluation of diluted spent wash on root length, shoot length, dry matter production and vigour index. These germination parameters increased up to 10 % dilution irrespective of the crops.

Muthalagi and Mala (2007) 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.

EFFECT ON HORTICULTURAL CROPS

Vegetables: Srivastava (1991) evaluated the paper mill and chlor-alkali plant effluent (CAP) on seed germination of healthy seeds of radish and onion in different dilutions 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. In bhendi the germination per centage was increased by 15% with tap water and 25% with spentwash (Hari *et al.*, 1994).

Ramana *et al.* (2002) conducted a laboratory experiment to study the effect of different concentrations (0, 5, 10, 15, 20, 25, 50, 75 and 100%) of distillery effluent (raw spent wash) on seed germination (%), speed of

germination, peak value and germination value in some vegetable crops viz., tomato, chilli, bottle gourd, cucumber and onion. The distillery effluent did not show any inhibitory effect on seed germination at low concentration except in tomato, but in onion the germination was significantly higher (84%) at 10% concentration as against 63% in the control. Irrespective of the crop species, at highest concentrations (75 and 100%), complete failure of germination was observed. The speed of germination, peak value and germination value also followed a similar trend and found that a concentration of 5% was critical for seed germination in tomato and bottle gourd and 25% in the rest of the crops. Based on the tolerance to distillery effluent, the crops studied have been arranged in the following order: cucumber>chilli>onion>bottle gourd>tomato. So the effect of the distillery effluent is crop-specific and due care should be taken before using the distillery effluent for pre-sowing irrigation purposes.

Sharma *et al.* (2002) conducted bioassay studies to assess the toxicity of raw and diluted distillery effluent on seed germination, seedling growth and pigment content of sugarbeet by collecting effluent samples from the main hole of the Sri Ganganagar Sugar Mill factory, in Rajasthan. Seeds kept moist in different dilutions (1, 5, 10, 20 and 30%) of effluent solution, along with double distilled water, which served as the control revealed that higher concentrations (>5%) of effluent were found to be toxic, however, the effluent can be used for irrigation purpose after proper dilution.

Dixit (2003) studied the effect of fertilizer factory effluents (0, 1, 2, 5, 10, 25, 50 and 100%) on seed germination of tomato cultivars PED, Pusa Ruby and Rupal-I. The percentage germination gradually decreased with increasing concentration of effluents. Germination increased with 25% effluent concentration. Higher concentrations (50 and 100%) showed a negative impact on germination

Soundarrajan and Pitchai (2007) found that application of spentwash diluted at higher level (50 times) has increased germination per centage, growth fruit yield and fruit quality of Bhendi in a pot culture experiment. In a study conducted by Yadav and Meenakshi (2007) to assess the toxicity of surgical effluent on seedling germination, seedling growth, biomass and crop yield of *Raphanus sativus* var. Pusa Chetki (Raddish) and *Hibiscus esculentus* versha uphar (Bhendi). The germination per cent decreased with increasing of the effluent concentration.

Spices and aromatic plants: Muthalagi and Mala (2007) found that 100% sewage concentration on *Trigonella foenum* (Fenugrick) 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

EFFECT ON TREE SPECIES

Gomathi and Oblisami (1992) stated that pulp and paper mill effluent could also be used for irrigating tree crops after proper dilution. Germination per centage decreased from 100 to 75% due to irrigation with paper mill effluent at 100% concentration. The length of the root and shoot and vigor index of the tree species viz., neem, pungam and tamarind, decreased considerably. But on application of effluent at concentrations of 25, 50, 75 and 100% at 100 mL day^{-1}. At 25 and 50% concentrations, the effluent had no inhibitory effect on germination. A 25% effluent was equal to that of normal water for irrigation.

Effects of tannery effluent on seed germination of *Acacia holosericea* and *Leucaena leucocephala* were studied. The effluent was diluted to 25, 50, 75 and 100% concentrations. Twenty five and 50% effluent inhibits seed germination and completely suppressed by 75 and 100% effluent. Even the chlorophyll and protein contents decreased with 75 and 100% effluent concentration (Karunyal *et al*., 1994).

Pandey and Soni (1994) stated that the lower concentration (10%) spentwash had enhanced germination in *Areca catechu* and *Dalbergia sissoo*. Karunyal *et al.* (1994) reported the effects of tannery effluent (25, 50, 75 and 100%) on seed germination of *Oryza sativa*, *Acacia holoserica* and *Leucaena leucocephala*. The germination was inhibited by 25 and 50% and prevented by 75 and 100% of the tannery effluent.

Thiruvaruldevi *et al.* (2006) evaluated the seed quality characters of neem with industrial effluents viz., tannin, textile dyeing, cement, rayon pulp and automobile both as raw and in different dilutions (10-50%) and revealed that on irrigation with raw material the reduction in germination was minimal due to tannin and rayon pulp irrigation, whereas the irrigation with dyeing and automobile effluent inhibited the germination completely. continuous irrigation with effluent was, however found to cause seedling damages, which was severe with textile dyeing, tannery and automobile effluents. However, with diluted effluent increased the germination and seedling vigour compared to raw effluent.

CONCLUSION

Review of work done by the various authors revealed that irrespective of the type of effluent, these could be well utilized for betterment of agricultural crops on proper

dilution to evate the lethality of the pollutants. This diluted effluent could be used both foe invigourating the seed and for further irrigating the crop or the nursery in case of tree seeds depending up on the availability of the effluent specific to site as the case may be giving way to utilize the waste material for betterment of the mankind with out causing ill effects to human and animals. The effluents on proper dilution can be also be materialiased as cash by proper sale of the product thus the review fresh up the idea of mutiutility of waste material.

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