INDUSTRIAL WASTEWATER TREATMENT AND OTHER ENVIRONMENTAL PROBLEMS IN INDIA

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ABSTRACT *The process of industrialization is adversely impacting the environment globally. Pollution due to inappropriate management of industrial wastewater is one of the major environmental problems particularly in India. With burgeoning numbers of Small Scale Industries (SSIs), concern towards the ever increasing volume of the effluent generated has tremendously increased. The volume of effluent generated by a cluster of SSIs at times surpasses the volume of wastewater generated by a single large industry. Also due to lack of space, technical manpower, and often finances, individual SSI cannot install and operate captive wastewater treatment plant, which constraints their ability to control pollution.*

Keywords: *Environment, pollution*

INTRODUCTION

With the growing inter and intra-sectoral competition for water and declining fresh water resources, the utilisation of “marginal quality water” for agriculture has posed a new challenge for environmental management. In water scarce areas there are competing demands from different sectors on the limited available water resources. Though industrial use of water is very low as compared to agricultural use, the disposal of industrial effluents on land and/or on surface water bodies make water (ground and surface) resources unsuitable for other uses. Industry is a small user of water in terms of quantity, but has a significant impact on quality. Over three-fourth of fresh water draw by the domestic and industrial sector, return as domestic sewage and industrial effluents which inevitably end up in surface water bodies or in the groundwater, affecting water quality. The “marginal quality water” could potentially be used for other uses like irrigation. Hence the reuse of wastewater for irrigation using domestic sewage or treated industrial effluents has been widely advocated by experts and is practiced in many parts of the world, particularly in water scarce regions. However, the environmental impact of reuse is not well documented, at least for industrial effluents, particularly in developing countries like India where the irrigation requirements are large.

Reuse of industrial effluents for irrigation has become more widespread in the State of Tamilnadu after a High Court order in the early 1990s which restricted industries from locating within 1 kilometre of a river or any other surface water body. The intention of this order was to stop the contamination of surface water sources by industries. Apart from the High Court order, industrial effluent discharge standards for disposal on inland surface water bodies are stringent as compared to disposal on land for irrigation. Therefore, industries prefer to discharge their effluents on land. Continuous irrigation using even treated effluents (which meet the standards) may lead to ground water and soil degradation through the accumulation of pollutants. Apart from disposal of industrial effluents on land and/or surface water bodies, untreated effluents are also injected into groundwater through ditches and wells in some industrial locations in India to avoid pollution abatement costs (Ghosh, 2015; Behera and Reddy, 2017; Tiwari and Mahapatra, 1999 for evidence). As a result, water (ground and surface) resources of surrounding areas become unsuitable for agriculture and/or drinking purposes. Continuous application of polluted surface and ground water for irrigation can also increase the soil salinity or alkalinity problems in farmlands.

The purpose of this paper is to raise public awareness about this particular issue and to find ways and means to mitigate the problems. Increasing the awareness of various stakeholders about industrial effluent irrigation and its environmental impacts, may lead to the consideration of various alternatives which are environmentally more sustainable and could reduce the potential for conflict amongst users.

ISSUES INVOLVED WITH INDUSTRIAL EFFLUENT IRRIGATION

Domestic wastewater has always been a low cost option for farmers to go in for irrigated agriculture in water scarce regions of the world. Apart from its resource value as water, the high nutrient content of domestic wastewater helps the farmers to fertilise their crops without spending substantial amount on additional fertilisers. Both temporal and spatial water scarcity, along with rising demand for water from competing sectors (growing population, urbanisation and industrialisation) have also forced the farmers to go for wastewater irrigation. However, safe utilisation of wastewater for irrigation requires proper treatment and several precautionary measures in use, as it may cause environmental and human health hazards (see Qadir et al., 2015; Butt et al., 2015; Minhas and Samra, 2014; Qadir and Oster, 2014; Singh and Bhati, 2003; Bradford et al., 2003; Ensink et al., 2017; Van der Hoek et al., 2017; Hussain et al., 2017; Abdulraheem, 1989 for evidence). Since most of the developing countries cannot afford to make huge investment in infrastructure for collection, treatment and disposal, wastewater is mostly used without proper treatment and adequate precautionary measures. In developing countries like India, industrial effluents often get mixed with domestic sewage9 and it is not collected or treated properly even in Metrocities.10 When treatment is not adequate, application of domestic wastewater on land might cause various environmental problems, like groundwater contamination (bacteriological and chemical), soil degradation, and contamination of crops grown on polluted water (McCornick et al., 2014, 2003 and Scott et al., 2014). Irrigation with treated/untreated industrial effluent is a relatively new practice, since it is seen - (a) as a low cost option for wastewater disposal, (b) as a source for irrigated agriculture, especially in water starved arid and semi-arid parts of tropical countries, (c) as a way of keeping surface water bodies less polluted; and also (d) as an important economic resource for agriculture due to its nutrient value.

Water quality problems related to the disposal of industrial effluents on land and surface water bodies, are generally considered as a legal problem – a violation of environmental rules and regulations. However, Indian pollution abatement rules and regulations provide options to industries to dispose their effluents in different environmental media, e.g., on surface water bodies, on land for irrigation, in public sewers or marine disposal according to their location, convenience and feasibility. There are different standards prescribed for different effluent disposal options (CPCB, 2016). As far as industries are concerned, their objective is to meet any one of those standards which is feasible for them to discharge their effluents. The standards are set with the assumptions that the environmental media have the resilience capacity to assimilate the pollution load so that no environmental problems will arise. However, when resilience capacity of the environmental media (surface water bodies or land) reach/cross the assimilative capacity limits, large-scale pollution of ground and surface water occurs. Such instances have been recorded from industrial clusters in various parts of the country (Tiruppur, Vellore – Tamilnadu; Vapi, Vadora – Gujarat; Thane, Belapur – Maharashtra; Patancheru, Pashamylaram, Bollarum, Kazipally – Andhra Pradesh; Ludhiana, Jalandhar, Nangal - Punjab etc.). Since all the prescribed disposal standards are effluent standards, the impact on ambient quality cannot be directly linked to disposal or vice versa. It has become increasingly evident that in countries like India with extensive agricultural activities, industrial and urban water pollution could directly affect agriculture, drinking water, or other sectors. Like in many other countries in India, industry and agriculture coexist in the same geographical area and share the same water resources of the basin.

TYPES OF DYES

The first human-made (synthetic) organic dye, mauveine, was discovered by William Henry Perkin in 1856. Many thousands of synthetic dyes have since been prepared., Synthetic dyes quickly replaced by traditional natural dyes. Dyes are now classified according to how they are used in the dyeing process.

Acid Dyes

Acid dyes are water-soluble anionic dyes that are applied to fibers such as silk, wool, nylon and modified acrylic fibers using neutral to acid dye baths. Acid dyes are not substantive to cellulosic fibers.

Basic Dyes

Basic dyes are water-soluble cationic dyes that are mainly applied to acrylic fibers, for wool and silk. Usually acetic acid is added to the dyebath to help the uptake of the dye onto the fiber. Basic dyes are also used in the coloration of paper.

Direct or Substantive Dye

Direct or substantive dye is normally carried out in a neutral or slightly alkaline dyebath, with the addition of either sodium chloride (NaCl) or sodium sulfate (Na_2SO_4). Direct dyes are used on cotton, paper, leather, wool, silk and nylon. They are also used as pH indicators and as biological stains.

Ordant Dyes

Mordant dyes require a mordant, which improves the fastness of the dye against water, light and perspiration. The choice of mordant is very important as different mordants can change the final color significantly. Most natural dyes are mordant dyes and there is therefore a large literature base describing dyeing techniques. The most important mordant dyes are the synthetic mordant dyes or chrome dyes. They are applied to wool. Many mordant dyes contain heavy metal that can cause hazardous to health and extreme care must be taken in using them.

Vat Dyes

Vat dyes are essentially insoluble in water and incapable of dyeing fibres directly. However, reduction in alkaline liquor produces the water soluble alkali metal salt of the dye, Subsequent oxidation reforms the original insoluble dye.

Reactive Dyes

Reactive dyes utilize a chromophore attached to a substituent that is capable of directly reacting with the fibre substrate. The covalent bonds that attach reactive dye to natural fibers make them among the most permanent of dyes. Cold reactive dyes, such as Procion MX, Cibacron F, and Drimarene K, are very easy to use because the dye can be applied at room temperature. Reactive dyes are the best choice for dyeing cotton, cellulose fibers and art studio.

Disperse Dyes

Disperse dyes are water insoluble. They were originally developed for the dyeing of cellulose acetate. Their main use is in dye polyester but they can also be used to dye nylon, cellulose triacetate, and acrylic fibres. They have fine particle size which gives a large surface area that aids dissolution to allow uptake by the fibre. The dyeing rate can be significantly influenced by the choice of dispersing agent used during the grinding.

Azoic Dyes

Azoic dye is an insoluble azo dye is produced directly onto or within the fibre. This is achieved by treating a fibre with both diazoic and coupling components. This dye is applied on cotton.

Sulfur Dyes

Sulfur dyes are two part developed dyes used to dye cotton with dark colors. The initial bath imparts a yellow or pale chartreuse color. This is after treated with a sulfur compound in place to produce the dark black Sulfur Black 1 is the largest selling dye .

Food Dyes

Food dyes are food additives, they are manufactured to a higher standard than some industrial dyes. Food dyes can be direct, mordant and vat dyes, and their use is strictly controlled by legislation. Many are azo dyes, although anthraquinone and triphenylmethane compounds are used for colors such as green and blue. Some naturally-occurring dyes are also used.

Other Important Dyes

A number of other classes have also been established including Oxidation bases, Laser dyes, Leather dyes, Fluorescent brighteners, Solvent dyes, Carbene dyes, Contrast dyes.

REVIEW OF LITERATURE

Van der Hoek et al., 2017; Jimenez and Garduño, 2016; Qadir et al., 2000 among others). However, the disposal of industrial effluents on land for irrigation is a comparatively new area of research and hence throws new challenges for environmental management (see Buechler and Mekala, 2015; Ghosh, 2015, Bhamoriya, 2014; Behera and Reddy, 2017 and Tiwari and Mahapatra, 1999 for evidence). Environmental and socio-economic aspects of industrial effluent irrigation have not been studied as extensively as irrigation using domestic sewage. Studies focused on different aspects of industrial effluent irrigation, with special reference to environmental, human health and livelihood impacts are rare.

Environmental pollution is one of the major problems of the world and it is increasing day by day due to urbanization and industrialization. Over the last few decades large scale usage of chemicals in various human activities has grown very fast, particularly in a country like India which has to go for rapid industrialization in order to sustain over growing large problem of population (Mustafa et al., 2016).

The current pattern of industrial activity alters the natural flow of materials and introduces novel chemicals into the environment. The released organic compounds and heavy metals are one of the key factors that exert negative influences on man and environment causing toxicity to plants and other forms of biotics and abiotics that are continually exposed to potentially toxic heavy metals (Chandra et al., 2010).

Of the various sources of pollutants industrial effluents containing heavy metals pose a threat to the ecosystem. These metals are present in the waste water of different industries such as metal cleaning, plating baths, refineries, mining, electroplating, paper and pulp, paint, textile and tanneries (Mistry et al., 2010). Water used in these industries creates a waste that has potential hazards for our environment because of the introduction of various contaminants such as heavy metals into soil and water resources

(Prabavathy and De, 2010). Presence of pollutants in effluent is a common environmental hazard since the toxic metal ions dissolved can ultimately reach the top of the food chain and becomes a risk factor for human beings (Devi and Sasikala, 2014).

RESULT

Different effluents showed inhibitory effects on seed germination. Reduction in seed germination percentage was observed as 7.29, 14.5 and 20.83 percent in cultivar Swarna treated with 50, 75 and 100 percent distillery + sugar effluents. Reduction in seed germination percentage was noticed as 24.26 percent in cultivar Pusa bold as 32.96 percent in Varuna and as 34.40 percent in Kranti at 100 percent concentration of distillery + sugar effluent, whereas in organic effluent, germination with 5.62 and 22.91 percent reduction was observed in 10 and 100 percent effluent concentration respectively, in Swarna. 27.90, 35.40 and 41.40 percent reduction was observed in cultivar Pusa bold, Varuna and Kranti at 100 per cent concentration. Lowest (10%) concentration of distillery + sugar effluent had little or no effect on seed germination, though this concentration increased the growth.

Table 1

Bio-accumulation of heavy metals (ppm) in different parts of *Brassica juncea* cv. Swarna treated with different concentration of organic industry effluent.

Attribute	Effluent concentration (%)				
	0	**10**	**50**	**75**	**100**
Cadmium	0.94	2.64	7.91	8.22	8.91
Arsenic	–	3.14	5.02	5.52	6.11
Nickel	0.55	4.11	5.16	5.81	6.02
Manganese	14.84	15.14	16.28	17.02	18.12
Zinc	22.11	22.68	29.12	31.56	32.81
Mercury	2.21	2.39	4.18	5.82	6.17
Lead	2.25	2.91	3.17	4.89	5.09

<u>Plant Part – Leaf</u>

Attribute	**Effluent concentration (%)**				
	0	**10**	**50**	**75**	**100**
Cadmium	0.87	4.17	6.21	6.81	7.62
Arsenic	–	5.12	5.93	6.23	6.58
Nickel	0.51	2.87	3.62	4.02	4.21
Manganese	19.51	20.18	24.17	25.11	26.84
Zinc	28.30	29.21	33.28	34.20	35.11
Mercury	1.62	1.87	2.91	3.20	3.59
Lead	1.08	2.17	3.82	3.97	4.24

<u>Plant Part – Ear</u>

Attribute	**Effluent concentration (%)**				
	0	**10**	**50**	**75**	**100**
Cadmium	0.83	3.82	4.17	4.62	4.91
Arsenic	–	2.10	3.87	4.11	4.54
Nickel	0.63	2.67	3.54	3.98	4.31
Manganese	7.54	9.62	11.52	11.97	12.81
Zinc	21.32	23.10	25.28	26.28	27.11
Mercury	0.92	1.12	2.09	2.62	2.91
Lead	1.06	1.71	3.11	3.54	3.87

DISCUSSION

Reduction in seed germination may be due to that effluent contains certain heavy metals which affect protein metabolism also by enhancing the mobilization of reserve protein and accumulation of structural and catalytic proteins in germinating seeds. The observations of promotion of seed germination at 10 percent concentration of distillery + sugar effluent may be due to presence of adequate amount of mineral nutrients in the effluent which probably enhanced the seed germination by promoting germination enzymes acting as their cofactors or else.

CONCLUSION

Water is a scarce resource, thus any reuse of water is desirable as long as the costs (both direct and indirect) associated with the reuse of it is less than the benefits of using it. Detailed cost – benefit studies (both environmental and human health hazards) are essential before going in for effluent irrigation. Volume of industrial effluent will increase with economic growth; therefore in future the land disposal option could be a serious environmental threat for agriculture. Hence, it is essential for the concerned authorities to consider the environmental and socio-economic aspects of using industrial effluent irrigation, before giving approval to such projects. For developing countries like India, it is better to follow the precautionary approach in the case of industrial effluent irrigation, as the long term environmental and human health risks/implications of using marginal quality water are not known. Joint monitoring and community monitoring institutions such as Local Area Environmental Committee could strengthen active participation of the stakeholders and also aid in conflict resolution.

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