International Journal of Advanced Technology in Engineering and Science www.ijates.com
Volume No.02, Issue No. 11, November 2014 ISSN (online): 2348 – 7550

IRRIGATION WITH UNTREATED URBAN WASTEWATER: ENVIRONMENTAL IMPACT AND ASSOCIATED HEALTH RISK

Geetanjali Chauhan
Department of Environmental Biology, A.P.S. University Rewa, Madhya Pradesh, (India)

ABSTRACT

The use of wastewater in growing crops is normally associated with some problems. One of such problems is health hazards posed to the farmers/farm workers, crop handlers, consumers and residents around the wastewater irrigated fields. It is to be noted that wastewater normally carry a potentially dangerous loads of pathogenic organisms and other contaminants such as heavy metals that have the potentials to pose some risks to public health. Degrading catchments and water shortage are the most immediate and arguably the biggest environmental issues affecting the world today. Wastewater is a valuable but under-utilized resource due to possible environmental contamination and fears of health risks. Effective expansion of wastewater use for irrigation purpose is currently stymied by a lack of knowledge and comprehensive tools. This paper describes ways to address this issue.

Keywords - Environmental Pollution; Health Risk; Microbiological Contamination; Untreated Irrigation; Wastewater.

I. INTRODUCTION

1.1 Environmental Issues Affecting the World Today: Wastewater Irrigation

In many countries urban wastewater is used to irrigate agricultural land. The use of wastewater for irrigation is a way of disposing urban sewage water with several advantages. Wastewater contains a lot of nutrients, which make the crop yields increase without using fertilizer. Furthermore, sewage water is an alternative water source in arid and semi-arid areas where water is scarce. Besides these advantages, wastewater can contain heavy metals, organic compounds and a wide spectrum of enteric pathogens which have a negative impact on the environment and human health (Scott, Zarazua and Levine 2000). In 1989 WHO set guidelines for the maximum number of bacteria and helminth eggs in wastewater used for irrigation to protect farmers and consumers of crops (WHO 1989). Treatment methods were developed to reduce the hazardous elements in wastewater before its use on agricultural fields. However, in many developing countries wastewater is still used without any treatment. Treatments facilities are not available, people are not aware of the health and environmental hazards and the WHO guidelines are not feasible. Knowledge about the costs and benefits of treatment in developing countries is limited, as is knowledge about the actual environmental and health risks of irrigation with untreated urban wastewater. Therefore, the International Water Management Institute started a study on benefits and costs of irrigation with urban wastewater in world today. Many cities of India use wastewater from their sewerage systems for irrigation. This water is used without any treatment since the

building of treatment plants is expensive, while farmers are willing to use the untreated wastewater. Farmers know that yields will increase by using this water. However, they are not aware of increased health risks and environmental concerns of using untreated wastewater. The survey described in this report was part of the study on benefits and costs of wastewater irrigation and focused on the health risks to the community due to heavy metal and other pathogenic contamination. Since infectious diseases due to enteric pathogens are common in India (Ministry of Environment and Forest, 2009), untreated wastewater is expected to contain a high concentration of heavy metals and excreted enteric pathogens. There is a potential health risk for all people who come in contact with this wastewater.

1.2 Environmental Drivers for Use of Untreated Wastewater

Farmers, their families and crop consumers might be at risk, because the vegetable grown in wastewater irrigated fields are mostly eaten uncooked. Therefore, toxic metals and/or the pathogens present in wastewater can contaminate these vegetables and pose a health risk to consumers (Blumenthal *et al.,* 1996). Human impacts on freshwater systems are substantial in most populated parts of the world. Over-extraction of freshwater, mainly for agriculture, has lead to significant degradation of rivers, lakes and aquifers. Liberation of water for the environment through substitution with wastewater has been promoted as a means of reducing anthropogenic impacts (Hamilton *et al.,* 2005ab). According to the water stress index i.e. the ratio of a country's total water withdrawal to its total renewable freshwater resources, about half of the countries of Europe are under water stress (Bixio 2005). Therefore, the key challenge facing many countries including India is to develop strategies to meet the increasing water demands of society but which do not further degrade the integrity of the environment. The other major environmental benefit from using wastewater is a reduction in pollution of waters receiving discharge of effluents. Reducing the volume of this discharge is also a powerful driver for wastewater use.

1.3 Environmental Risks and Sustainability

Wastewater irrigation poses several threats to the environment via contamination by nutrients, heavy metals, and salts. Increased loads of nitrates in wastewater may increase the risk of groundwater contamination (Stagnitti *et al*., 1998). The risks can be markedly reduced, however, by appropriately matching plant production systems to effluent characteristics (Snow *et al.,* 1999). High-yielding crops with large amounts of nitrogen in their biomass would be more effective than tree plantations at reducing nitrate leaching. However, the most important sustainability constraints are due to salinity and sodicity. Salinity is a pragmatic constraint for many horticultural reuse schemes. For example, at Australia's Werribee horticultural irrigation scheme, which commenced in 2005, salinity concerns lead to a precautionary approach where the wastewater is mixed with river water before being (MWSRW 2004). Sodicity induces changes in the soil's physical properties, the most notable effect being the dispersion of soil aggregates. Dispersion, in combination with other processes, such as swelling and slacking, can affect plants through decreasing the permeability of water and air through the soil, water-logging and impeding root penetration.

1.4 Health Risk from Use of Wastewater in Agriculture

Wastewater irrigation poses a number of potential risks to human health via the consumption of or exposure to pathogenic microorganisms, heavy metals, harmful organic chemicals such as endocrine disrupting compounds and pharmaceutically-active compounds (Stagnitti *et al.,* 1999). Of these, pathogenic microorganisms are generally considered to pose the greatest threat to human health (Toze, 2006).

1.5 Health Risk Due To Microbiological Contamination

In areas where infectious diseases due to enteric pathogens are common, these pathogens are found in very high concentrations in the wastewater, including bacteria, viruses, protozoans and parasitic worms. The symptoms and diseases associated with such infections are also diverse including typhoid, dysentery, gastroenteritis, diarrhoea, vomiting and malabsorption. The concentration of pathogens in wastewater is dependent on the source population and the susceptibility to infection varies from one population to another. When this water is used for irrigation without any treatment the pathogens are applied to the agricultural land. This is a potential health risk to people exposed to it, such as field workers and their families, consumers and handlers of wastewater-irrigated crops and people living in the neighborhood, passing the fields frequently. However, the actual health risk, which is the risk of people falling ill, is lower than the potential health risk (WHO 1989). The potential health risk is only based on the number of pathogens in the wastewater, while the actual health risk depends on three more factors:

- ***The time pathogens survive in water or soil***
- ***The dose in which pathogens are infective to a human host***
- ***Host immunity for pathogens circulating in the environment.***

The highest health risk is theoretically for helminthes infections (table 1). Compared with other pathogens, helminthes persist for long periods in the environment, host immunity is low to nonexistent and the infective dose is small (Gaspard, Ambolet and Swartzbrod 1997). Epidemiological studies have shown that the actual risk of infection for people exposed to wastewater is the highest for the roundworm *Ascaris lumbricoidus*, the whip-

Table 1: Health Risk from Use of Wastewater in Agriculture

Type of pathogen / infection	Relative excess of frequency of infection or disease
Intestinal nematode infections (*Ascaris lumbricoidus, Trichuris trichiura,* hookworm)	High
Bacterial infections Bacterial diarrheas(e.g. cholera, typhoid)	Lower
Viruses Viral diarrheas Hepatitis A	Lowest

Source: World Health Organization 1989

worm *Trichuris trichiura* and the hookworms *Ancylostoma duodenale* and *Necator americanus* (WHO 1989, Cifuentes 1993, 1994). The risk of acquiring a bacterial, protozoan or fungal infection due to exposure to wastewater is much lower. The survival time of these pathogens in the environment is lower and there is more host immunity. The lowest risk is for viral infections, mainly due to high host immunity for virus infections (WHO 1989, Schwartzbrod 1995). However, an outbreak of cholera due to consumption of wastewater irrigated vegetables was reported in Israel (WHO 1989) and a significant higher prevalence of *Entamoeba histolytica* infections and diarrhea in children was observed in a wastewater-irrigated area in Mexico (Cifuentes 1993, 1994). Although irrigation with wastewater has been practiced for centuries, the first health regulations were developed in the early 20th century. With the growing awareness and fear of transmission of communicable diseases, strict guidelines were set. However, these first health regulations lacked an epidemiological base and

Table 2: Recommended Microbiological Quality Guidelines for Wastewater Used For Crop Irrigation

Category	Reuse conditions	Exposed group	Intestinal nematodes2 (arithmetic mean no.of eggs per liter3)	Faecal coliforms (geometric mean no. per 100 ml3)	Wastewater treatment expected to achieve the required microbiological quality
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks	Workers, consumers , public	< 1	< 10004	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees5	Workers	< 1	No standard recommended	Retention in stabilisation ponds for 8-10 days or equivalent helminth and faecal coliform removal
C	Localized irrigation6 of crops in category B, if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment are quired by the irrigation technology, but not less than primary sedimentation

Source: World Health Organization (1989)

were too strict. In 1989 WHO set more realistic guidelines, based on epidemiological evidence (table 2) (Shuval 1991). However, recent evaluations show that these guidelines protect crop consumers, but not necessarily field workers and their families, especially children (Blumenthal *et al*, 1996). Therefore, new guidelines are in the development stage. Besides the microbiological contamination, chemical and organic pollutants, which are toxic

for humans can also be present in wastewater. Of main public health concern are organic chemicals including pesticides and heavy metals such as lead and cadmium which can accumulate in crops, soil and groundwater (Hespanhol 1993). Although these chemical and organic pollutants can cause health problems, the emphasis of this study was on health hazards from microbiological contamination of wastewater. Chemical and organic pollution of the wastewater irrigation was also assessed and reported at http://www.ijsrp.org/research-paper-0914/ijsrpp3360.pdf; http://www.ijtra.com/view/relationship-between-heavy-metaland transfer-factor-fromsoil-to-vegetable-grown-in-waste-water-irrigated-area-of-rewa-mp india.pdf; and http://www.ijates.com/images/short_pdf/1409234095_P444-460.pdf

II. CONCLUSION AND RECOMMENDATION

The world's freshwater resources are under strain. Use of untreated wastewater, in concert with other water conservation strategies, can help lessen anthropogenic stresses arising from over-extraction and pollution of receiving waters. However the disposal of wastewater on agricultural fields has a lot of benefits, the use of this water without any treatment poses serious health risks to farmers and their children as well as environmental risks such as transport of harmful contaminants in soils, pollution of groundwater and surface-water, degradation of soil quality e.g. salinisation, impacts on plant growth, the transmission of disease via the consumption of wastewater-irrigated vegetables, and even increased greenhouse gas emissions. The prevalence of diarrheal diseases and hookworm infections was very high in farmers working on wastewater irrigated fields, while in children of these farmers the prevalence of these diseases was also high. Besides farmers and their families, there is an indication that crop consumers might have a higher chance to acquire an infection with hookworm. Therefore, protective measures are required for farmers, their families and crop consumers. However, an appropriate form of treatment of wastewater for helminth eggs and faecal coliform bacteria before application to the fields is highly recommended. If treatment is not possible because of the high costs, other protective measures should be taken. Low cost interventions could include information on hygiene behavior for farmers, wearing of shoes and gloves while working in wastewater irrigated fields, regular treatment of farmers and their families with antihelmintic drugs and crop restrictions in wastewater irrigated fields.

REFERENCES

[1] Bixio D, De Koning J, Savic D, Wintegens T, 2005. Wastewater use in Europe. In *Integrated Concepts in Water Recycling* pp 80-92 (University of Wollongong, NSW, Australia).

[2] Blumenthal, U. J., D. D. Mara, R. M. Ayres, E. Cifuentes, A. Peasey, R. Stott, D. L. Lee and G. Ruiz-Palacios. 1996. Evaluation of the WHO nematode egg guidelines for restricted and unrestricted irrigation. *Water Science and Technology* 33(10-11):277-283.

[3] Chauhan, G., Chauhan, U.K. (2014). Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Rewa (M.P.), India. International Journal of Advanced Technology in Engineering and Science, Volume No.02, Issue No. 08, pp 444-460; ISSN (online): 2348 – 7550.

[4] Chauhan, G., Chauhan, U.K. (2014). Relationship between heavy metal and transfer factor from soil to vegetable collected from waste water irrigated area of rewa (m.p.) india-"International Journal of Technical Research and Applications e-ISSN: 2320-8163, www.ijtra.com Volume 2, Issue 5 (Sep-Oct 2014), PP. 37-41".

[5] Chauhan, G. Chauhan, U.K.(2014). Human health risk assessment of heavy metals via dietary intake of vegetables grown in waste water irrigated area of Rewa, India -"International Journal of Scientific and Research Publications (IJSRP), Volume 4, Issue 9, September 2014 Edition".

[6] Cifuentes, E., U. Blumenthal, G. Ruiz-Palacios, S. Bennett, M. Quigley, A. Peasey and H. Romero-Alvarez. 1993. Problemas de salud asociados al riego agricola con agua residual en Mexico. *Salud Publica de Mexico* 35(6):614-619.

[7] Cifuentes, E., U. Blumenthal, G. Ruiz-Palacios, S. Bennett and A. Peasey. 1994. Escenario epidemiologico del uso agricola del agua residual: el valle del mezquital, Mexico. *Salud Publica de Mexico*. 36(1):3-9.

[8] Gaspard, P., Y. Ambolet, and J. Schwartzbrod. 1997. Valorisation des boues de stations d'épuration envue de l'amélioration des sols destinés à l'agriculture: contamination parasitaire et modélisation en vue de la gestion du risque sanitaire. *Bulletin de l' Academie Nationale de Medicine* 181(1):43-56.

[9] Hamilton AJ, Boland A, Stevens D, Kelly J, (2005a). Position of the Australian horticultural industry with respect to the use of reclaimed water *Agric Water Manage* 71, 181–209

[10] Hespanhol, I. 1993. *Reuse of community wastewater: health and environmental protection – research needs.* In: FAO, Integrated rural water management: Proceedings of the Technical Consultation on Integrated Rural Water Management, Rome, Italy, 15-19 March 1993. Rome, Italy: FAO. 121-138.

[11] Ministry of Environment and forest. 1999. Regulation on waste management system and *National feed back report*. New delhi, India; Gov. of India.

[12] MWSRW 2004. Melbourne Water and Southern Rural Water. Use of recycled water in the Werribee Irrigation District: regional environment improvement plan 104 pp.

[13] Schwartzbrod, L. 1995. *Effect of human viruses on public health associated with the use of wastewater and sludge in agriculture and aquaculture.* Geneva, Switzerland: World Health Organization.

[14] Scott, A. C., J. A. Zaraza and G. Levine. 2000. *Urban-wastewater reuse for crop production in the watershort Guanajuato river basin, Mexico*. IWMI Research report 43. Colombo, Sri-Lanka: International Water Management Institute.

[15] Shuval, H. I. 1991. Health guidelines and standards for wastewater reuse in agriculture: historical perspectives. *Water Science and Technology* 23:2073-2080.

[16] Snow VO, Dillon PJ, Bond WJ, Smith CJ, Myers BJ, 1999. Effect of plant production system and climate on risk of groundwater contamination from effluent irrigation *Water* 26, 26-29

[17] Stagnitti F, Sherwood J, Allinson G, Evans L, 1998. Investigation of localised soil heterogeneities on solute transport using a multisegement percolation system. *NZ J Agric Res* 41, 603-612

[18] Stagnitti F 1999. A model of the effects of nonuniform soil-water distribution on the subsurface migration of bacteria: Implications for land disposal of sewage, *Math Computer Mod*, 29, 41-52

[19] WHO (World Health Organization). 1989. *Health guidelines for the use of wastewater in agriculture and aquaculture.* WHO Technical Report Series 778 Geneva, Switzerland: World Health Organization.

[20] Toze, S 2006. Reuse of effluent water-benefits and risks *Agric Water Manage* 80, 147-159