POTENTIAL BENEFITS AND RISKS OF WASTEWATER USE

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ABSTRACT

Wastewater is used to irrigate in many forms. It can be used as treated (reclaimed water) or untreated (raw wastewater) and it can be applied directly to crops or indirectly after discharge and dilution with water from rivers or reservoirs. Sometimes reuse is part of a planned project, but most of the time—and particularly in developing countries—it just happens. In industrialized countries water reuse is part of a strategy to protect water bodies and to reduce wastewater treatment costs. It is usually performed only after high ecological standards of wastewater treatment have been achieved, and as a consequence reclaimed water has a low organic matter and nutrient content. In contrast, in developing countries reuse is frequently a spontaneous response to a shortage of water and job opportunities. It is generally practiced with "poor quality" water (even raw wastewater), which farmers like for its fertilizing properties but mostly because it is the only way to earn a living. Wastewater can even be used for agricultural irrigation in cities. This "urban agriculture" is practiced in urban and peri-urban areas of arid or wet countries, depending on wastewater availability, local demand for fresh food products, and people living on the verge of poverty who have no job opportunities. Wastewater flowing in open channels is used to irrigate very small plots of land where trees, fodder, or any other product that can be introduced to the market in small quantities (flowers and vegetables) or be used as part of the family diet are grown (Cockram and Feldman 1996; Ensink et al.2004). Like any activity, the use of wastewater to irrigate has both advantages and drawbacks. The major advantages of using wastewater for agricultural irrigation are- it permits higher crop yields, year-round production, and enlarges the range of crops that can be irrigated, particularly in (but not limited to) arid and semi-arid areas, recycles organic matter and other nutrients to soils, it reduces the cost of fertilizers (or simply makes them more accessible to poor farmers) and also reduces the use of synthetic fertilizer. This paper discusses these aspects, and based on practical experiences it proposes ways to obtain maximum benefits while reducing the risks.

Keywords: Wastewater, Agriculture, Irrigation, Reuse, Recycle, Environment, Soil, Ecology

1. Introduction

Wastewater from various sources is used for irrigation the world over without much attention paid to its quality. It is reported that at present, approximately 20 mill. ha (7%) of arable land worldwide are irrigated with wastewater. The unreported use of wastewater in agriculture can be even more. It is common in urban and peri-urban areas of the developing world, where insufficient financial resources and institutional capacities constrain the installation and operation of adequate facilities for proper wastewater collection and treatment. Apparently, wastewater use in agriculture has certain benefits viz. providing water and nutrients for the cultivation of crops, ensuring food supply and reducing the pressure on fresh water resources. However, wastewater is also a source of pollution, and can affect the health of crops/plants, humans and animals. The soil, water and the environment too comes under threat if safe practices are not adopted. As populations and urban areas are growing and water scarcity is increasing, it is expected that, in the near future, the use of wastewater in agricultural irrigation will increase further.

Safe use of wastewater to augment agricultural production is an important water resources issue that needs to be addressed at the soonest. Sincere efforts are needed in this direction and “safe use guidelines and practices” are to be incorporated and implemented in national, state, regional and local policies. The key word here is ‘safe wastewater’ instead of “wastewater” by treating it as a valuable resource with immense potential benefit.

HRM King Willem-Alexander of the Netherlands, in his former role as Chairman of the UN Secretary-General’s Advisory Board on Water and Sanitation addressing the 6th World Water Forum in Marseille, France on 12th March 2012 stressed the convergence of drinking water and sanitation issues in wastewater, calling it a-“…challenge for which we need multiple solutions from all sectors and at all levels. He pointed out that right now more than 90% of the world’s wastewater is discharged untreated into oceans, rivers or wherever else it can go. Given demographic trends, coupled with climate change impacts, this is a disaster in slow motion that will grow in proportion and impact. We need solutions for wastewater management, not only of human sewage, but also of industrial, agricultural and urban wastewater. Wastewater management can help meet multiple objectives and offers huge potential for a green economy” (UNSGAB, 2013). He went on to state: “We know that in many parts of the world, wastewater is already used for agriculture. This practice should be encouraged, but it must be done safely, with the use of guidelines, such as the globally accepted World Health Organisation guidelines for wastewater reuse. Safe water reuse is a solution, since it promotes food security in the future” (Ibid, 2013).

It is to be noted that wastewater presents a challenge and an opportunity. On one hand, its nutrients can be used for agriculture while on the other there is limited space for land-based treatment and reuse of wastewater aa needed.

Fig. 1: Irrigation with wastewater near a polluted stream

While many of the developed countries implement policy guidelines/norms pertaining to wastewater use, in many other countries, especially in the developing world, use of wastewater is an unregulated practice due mainly to reasons mentioned above. The cause of concern is that lack of implementation of proper guidelines and safety standards can lead to an otherwise avoidable aggravation of health risks that could result in significant secondary impacts and entail heavy cost to the exchequer.

2. Drivers of Wastewater Use in Agriculture

The primary drivers of wastewater use in agriculture are rapid population growth requiring more food, increasing urbanization (particularly in cities of the developing world), increased water scarcity and stress and agricultural water demand for urban and peri-urban food production. In high-income countries, the main driver for reclaimed wastewater use is water scarcity, the underlying objective of which is to ensure health for their citizens, conservation of fresh water and protection of the environment.

As far as the developing world is concerned, the key drivers are poverty and insufficient financial and coping capacities that collectively constrain the establishment of comprehensive wastewater treatment and management systems required for proper collection, treatment and use of wastewater. However, the use of untreated wastewater is not limited to the countries and cities with the lowest gross domestic product (GDP), but is also a common practice in many middle-income countries as well (Raschid-Sally and Jayacody, 2008).

3. Technological Perspective

It is a matter of relief that technologically, the issue of handling, collection and treatment of wastewater is well within our control and results achievable. Many countries, however, do not have access to this technology or do not have the human capacity and financial resources to operate such treatment plants efficiently in order to treat all effluents prior to discharging into the environment or reuse.

4. Types of Wastewater

The wastewater used for agricultural irrigation has different sources and covers wastewater of different qualities, ranging from raw to diluted, generated by various urban activities (Raschid-Sally and Jayakody, 2008).

The most common types are presented here. **(a) Urban wastewater:** It is usually a combination of one or more of the following:

- Domestic effluent consisting of black water (excreta, urine & associated sludge) and greywater (kitchen & bathroom wastewater)
- Effluent from commercial establishments and institutions, including hospitals
- Industrial effluent
- Storm water and other urban runoff.

(b) Treated wastewater: It is the wastewater that has been processed through a wastewater treatment plant and subjected to one or more physical, chemical and biological processes to improve its quality for reuse.

(c) Reclaimed or recycled water: It is treated wastewater that can officially be used under controlled conditions for beneficial purposes, such as irrigation.

(d) Greywater: It is particularly suitable for reuse. It is generated from households not connected to a sewerage system and can be treated and used for irrigation of home gardens and trees. It is an important component of water conservation. It comprises 50-80% of residential wastewater and offers great potential as an economic and resource conservation component of integrated water resource management in dry areas.

5. Ways of Using Wastewater

As with the different types of wastewater listed above, there are also different ways in which wastewater can be used. These are:

(a) Direct use of untreated wastewater from a sewage outlet occurs when it is directly disposed of on land where it is used for cultivation.

(b) Direct use of treated wastewater occurs when wastewater has undergone treatment before it is used for irrigation or other purposes.

(c) Indirect use of treated or untreated urban wastewater occurs when water from a river receiving treated/untreated urban wastewater is abstracted by farmers downstream for agriculture. This occurs when cities lack a comprehensive sewage collection network and when drainage systems discharge collected wastewater into rivers.

(d) Planned use of wastewater refers to the conscious use of wastewater either raw (i.e. untreated) or diluted (i.e. treated). However, most indirect use occurs without planning.

5. Benefits and Risks of Wastewater Use

Wastewater use in agriculture can be viewed as a benefit, providing water and nutrients for the cultivation of crops as well as a source of pollution, a threat affecting the health of users, consumers and the environment. Hussain et al. (2001) developed an overview of the potential benefits and risks arising from the use of wastewater in agriculture.

5.1 Benefits: Wastewater as a Resource

If managed properly and guidelines for utilization are followed, wastewater can provide beneficial effects for society, the economy and the environment.

First of all, components found in wastewater can contain useful nutrients required by plants that can reduce the cost of input of artificial fertilizers (that have negative environmental impacts associated with its use & production).

- ✓ Farmers therefore benefit through increased productivity and yields and faster growing cycles, while decreasing their needs for artificial fertilizers and additional water sources (Corcoran et al., 2010).
- ✓ In urban areas without alternative water supplies, wastewater is an advantageous resource because it is available all year round and is a low-cost option for farmers.
- ✓ There are also potentially significant positive health effects from improved food supply and nutrition in arid and food-insecure areas. To date, a systematic global assessment of the positive health benefits of the use of wastewater in agriculture has not been conducted and positive health benefits versus health risks will vary widely depending on the setting e.g. subsistence-level farmers who can benefit most in terms of improved food security and nutrition are also at the highest risk of negative health impacts, especially where untreated wastewater is used for irrigation. Conversely, in settings where alternative water sources are limited, treatment quality is high, and farming practices and food processing are advanced, potential benefits are likely to significantly outweigh risks. In any context, efforts should be made to quantify positive health impacts on nutrition and food security and weigh them against the potential negative health impacts discussed in the next section.
- ✓ There are, of course, still many instances where farmers either have no other option but to use marginal-quality water resources (such as in regions where reliable water supplies are lacking and discharge of municipal wastewater into the environment pollutes water bodies), or where farmers are unaware that they are directly using wastewater (such as when farmers are located downstream of large cities where wastewater is being dumped into open water viz. nearby streams, lakes etc). In recognition of the potential benefits of wastewater, especially in urban and peri-urban agriculture, planned use of wastewater for irrigation is an increasingly

important area of water resource development and management. This is a driver for wastewater use in both developing and developed countries, especially in water-scarce areas where alternative supplies are lacking. To elucidate this, an example is presented.

Population of a city= 500,000 Water consumption= 200 ltr/day per person.

Volume generated= 85,000m^3/d (30 Mm^3/year) of wastewater, assuming 85% inflow to the public sewerage system. If treated wastewater effluent is used in carefully controlled irrigation at an application rate of 6000 m^3/ha/year, an area of some 5000 ha could be irrigated. In addition to this economic benefit, the fertilizer value of the effluent is important. Typical concentrations of nutrients in treated wastewater effluent from conventional sewage treatment processes are given below:

Nitrogen (N) - 50 mg/l Phosphorus (P) - 10 mg/l Potassium (K) - 30 mg/l

Assuming application rate of 5000 m^3/ha/year, the fertilizer contribution of the effluent would be:

N - 250 kg/ha. year P - 50 kg/ha. year K - 150 kg/ha. year

Thus, all of the nitrogen and much of the phosphorus and potassium normally required for agricultural crop production would be supplied by the effluent. Further, other valuable micronutrients and the organic matter contained in the effluent will provide additional benefits.

5.2 Potential Risks of Wastewater Use

Potential benefits apart, wastewater use also poses high health and environmental risks if no additional measures are applied. Untreated wastewater generated from cities and industries potentially contains a wide range of different constituents (pathogens, organic compounds, synthetic chemicals, nutrients, organic matter and heavy metals). The suspended or unsuspended components carried along in the water from different sources (point as well as non-point) affect the water quality.

5.2.1 Health Risks

Health risks from wastewater use may manifest directly as outbreaks of food, water and vector-borne diseases, or less visible yet persistent diseases (e.g. intestinal helminth infections or diarrheal diseases) and non-communicable diseases resulting from exposure to heavy metals from industry or household detergents contained in the wastewater. Indirect health effects are also possible through contamination of drinking water sources, recreational water with nitrates or the production of toxic cyanobacteria. In addition, there have been emerging concerns related to micro-pollutants such as pharmaceutical residues. The 2006 WHO Guidelines for Safe Use of Wastewater, Excreta and Greywater summarize the array of pathogens and pollutants that can be found in wastewater, as well as summarizing the results of studies on human health risks posed by wastewater irrigation, especially from pathogen contamination.

- ✓ Health risks of concern are context-specific. In low-income countries/areas risks from microbiological contaminants are more since populations are most affected by diarrheal diseases and helminth infections related to poor sanitation. In higher income settings where microbiological risks are largely under control, chemical pollution and emerging pollutants are a larger public concern. The greatest health risks are associated with crops that are cultivated in close proximity to the soil and eaten raw, such as salad crops, onions or radishes.
- ✓ Intestinal helminths are the most likely infection in places where wastewater is used without adequate treatment due to the long survival time of their eggs (up to several years in water and soil).

- ✓ Polluted canals and streams expose farmers, children and other inhabitants to pathogens, pollutants and bacteria. Intestinal worm infestations have been shown to pose the greatest risk for occupational exposure (Drechsel et al., 2010).
- ✓ Serious diseases such as diarrhea, ascariasis and schistosomiasis, which cause a significant burden of diseases and potentially lead to death, are among the major wastewater-related diseases.
- ✓ The closer the farmers and consumers are to the source of pollution, the more vulnerable they are. Hence, consumers and marginalized communities living around agricultural regions where untreated wastewater is used are particularly exposed to risks. Further downstream, the concentrations of pathogens decline and become less harmful.
- ✓ Health implications linked to the use of untreated and contaminated wastewater can also result in substantial secondary impacts.
- ✓ In effect, polluted water causes child mortality. Thus, unmanaged wastewater can be regarded as a vector of disease (Corcoran et al., 2010).

5.2.3 Environmental Risks

The generation and discharge of wastewater into water bodies can cause significant impacts on the environment. Where irrigation with untreated, inadequately treated and/or diluted wastewater cannot be avoided or is common, negative impacts on irrigated crops, soils and groundwater are likely, which can affect not only human but also environmental health.

Wastewater contains different types and levels of undesirable constituents, depending on the source from which it is generated and the level of its treatment. In addition to organic chemicals, debris and solutes, the non-pathogenic components of wastewater can comprise undesirable salts or metals and metalloids in toxic concentrations. Eutrophication is one of the major prevalent global problems affecting the health and functioning of marine and freshwater ecosystems. Studies indicate that, through current agricultural practices and related run-off, approximately 80 million tonnes of nitrogen and 10 million tonnes of phosphorous discharge into inland waterways and coastal zones each year, which far exceeds all natural inputs. Together, such processes can exacerbate potentially toxic algal blooms and affect profound changes in biodiversity, such as devastating hypoxic events and an enhancement of dead zones, which in turn can lead to massive economic losses across many sectors (Rockström et al., 2009). It is estimated that up to 90% of wastewater produced flows into coastal zones and contributes to a rise in marine dead zones, already covering an area of about 2.45×10^5 km^2, equivalent to the global area of coral reefs (Corcoran et al., 2010).

Diverse toxic pollutants (agricultural and industrial chemicals) from land-based sources such as organic compounds and heavy metals to personal-care products and pharmaceuticals make their way into both fresh and marine waters, which have far-reaching impacts. From 1999 to 2002, for instance, the run-off of agricultural herbicides resulted in the deterioration of 30 km^2 of mangrove in north-east Australia (Duke et al., 2005). Cities on the coast depend on the marine ecosystem services for their two main economic activities viz. tourism and fishery. A loss of the services could have significant secondary impacts, resulting in a contamination of fish stocks, algae blooms, rise of marine dead zones and loss of food livelihood and security.

6. Issues to be Addressed

As far as irrigated agriculture is concerned, the chemical constituents that need to be addressed can be divided into the following:

- ✓ High concentrations of nutrients (N, P, K, Mg, Ca) as they suppress other nutrients or otherwise negatively affect plant growth;

- ✓ Metals and metalloids (cadmium, nickel, chromium, zinc, lead, arsenic, selenium, mercury, copper & manganese);
- ✓ Salts and specific ionic species such as sodium, boron and chloride;
- ✓ Persistent Organic Pollutants (POPs), such as pesticides and ‘emerging contaminants’, such as residual pharmaceuticals, endocrine disruptor compounds and active residues of personal care products, among others.

7. What is Required?

The following points need consideration while using wastewater for irrigation.

- ✓ **Use of wastewater has to be continuously monitored to get optimal results due to the fact that effectiveness in irrigation depends on the match between its composition and the ecology of the soil.**
- ✓ **The major concern is the pathogens and it is better to avoid wastewater from industrial sources and use domestic wastewater.**
- ✓ **An effective and implementable policy on wastewater reuse in agriculture is needed considering wastewater recycling as part of the national/state water policy.**

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