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Pilot Review Study on the Importance of Treated Agro-Industrial Wastewater to Reuse for Irrigating Agriculture

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Abstract
The main purpose this review study is to present fundamentals of wastewater conservation and treatment method amid at using it for irrigating agriculture in a manner understandable to those most concerned with such knowledge and also to provide the wastewater users with an insight into the many ways in which they are dependent on soil and water for survival. In most parts of Ethiopia, the water needed for crop production is provided mainly by rainfall. These days; however, the effectiveness and sufficiency of rain fall, even in high rainfall receiving areas, is interrupted by its erratic occurrence, uneven distribution, poor soil and water managements. There is also scarcity of water during dry seasons. To achieve this, integrated participation and coordinated efforts of the different institutions is highly considered. After introducing provisions and expressions of wastewater use, this study highlights their global drivers and significance using examples from various parts of the developing world. It is useful in the discussion to differentiate between unplanned use of wastewater resultant from deprived sanitation, and planned use which tries to address matters such as economic or physical water scarcity. Both types of wastewater use can have significant socio-economic benefits but also institutional challenges and risks which require various management approaches. Based on the laboratory test results and the field experimental research activities conducted on cereal crops like wheat and barley as well as the pulse crops of the field pea and Faba bean crops which planted in the agro-industrial wastewater of Asella Malt Factory have performed very well at 25%, 50% and 75% of fresh water and wastewater dilutions in favor of their intensive growth rate performance of the seeds. There is a need for the consequent study to apply the principles of wastewater management and treatment method to use it for irrigating agriculture. The author links wastewater and health to the establishment and implementation of effective, affordable and efficient options for risk reduction. Under the conditions applied in this study, the reuse of treated agro-industrial wastewater for irrigation can be considered an effective way to cope with agricultural water shortage in the Mediterranean area. We can expect the entire information quantified in this paper will influence further applied multidisciplinary research on wastewater use related risk and its alleviation.

Keywords: Agro-Industrial Wastewater, Crop Growth Performance & Yield Quality, Faecal Sludge & Wastewater Reuse.

Introduction

In many developing countries, agro-industrial wastewater is used for irrigating agriculture both with and without treatment; in the final occurrence, it might be in diluted or undiluted form. While wastewater treatment and recycling for various purposes has been well documented, the agricultural use of raw and diluted wastewater has only recently been brought to the foreground as a phenomenon that needs attention [1, 2, 3]. The capacity of wastewater produced by domestic, agro-industrial, and commercial sources has raised with population growth, urbanization, improved living conditions, and economic development. The effective usage of wastewater has also enlarged, as millions of small-scale farmers in urban and peri-urban areas of developing countries depend on wastewater or wastewater contaminated water sources to irrigate high-value edible crops for urban markets, often as they have no another sources of irrigation water. Unwanted elements in wastewater can hurt human well-being and the environment. Therefore, wastewater irrigation is an issue of concern to public organizations accountable for keeping public well-being and environmental quality. For various reasons, many developing countries are still unable to implement comprehensive wastewater treatment programs.

Thus in the near term, risk management and conditional solutions are needed to avoid and prevent different impacts from wastewater irrigation. The amalgamation of source control, and farm-level and post-harvest measures can be used to protect farmworkers and consumers. The WHO rules revised in 2006 for wastewater use suggest measures beyond the traditional recommendations of producing only industrial or non-edible crops. As in many situations it is impossible to enforce a change in the current cash crop pattern, or provide alternative vegetable supply to urban markets ([2, 3]. There are quite a lot of opportunities for refining wastewater management through enhanced policies, institutional discussions and financial mechanisms, which would diminish the dangers in agriculture.

Effluent standards combined with incentives or enforcement can motivate improvements in water management by household and industrial sectors discharging wastewater from point sources. The use of unprocessed wastewater or contaminated water in general, boot-up torrential dangers to human health since it may have extract-related pathogens such as bacteria, viruses, protozoan, multi-cellular parasites, skin irritants, and toxic chemicals like any kind of substantial materials, morsels, hunk and paring metals, pesticides and pesticide residues. When agro-industrial wastewater is used in agriculture, pathogens and certain chemicals are the primary dangers to human health by exposure through different ways. These exposure ways mainly contact with wastewater to the farmers, field workers, and nearby communities as well as consumption of wastewater-grown producers and consumers.

In addition, contamination may be due to poor post-harvest handling that can also lead to cross-contamination of farm produce. The agricultural use of treated, partially treated, or untreated wastewater or surface water contaminated with industrial wastes is common. An estimated 20 million hectares worldwide are irrigated with wastewater, more of it untreated than treated wastewater [4, 5]. This misbalance in favor of untreated wastewater will continue to increase as long as the pollution of streams, by effluents from growing urban populations is not matched by treatment facilities.

The increasing global scarcity of good-quality water will turn wastewater irrigation from an undesirable phenomenon into a necessity wherever agricultural water demand is not met by supply. This is not only the case in drier regions but anywhere where farmers seek land and water to address market demand. Common examples are urban and peri-urban areas in most developing countries where clean water sources are hardly sufficient even to meet domestic demand. Describing the present use of wastewater, malt barley washed-out extracts, and sludge in the agricultural practices of developing countries is not an easy task. On the one hand, there is a lack of reliable and sufficient information and, on the other; the available information does not use uniform terms and units to describe these practices. The public lack of important information about the use of agro-industrial wastewater is rather due to the informal nature of putting into practice or even, in some other cases, to the intention not to make known the existing alternatives in order to use the wastewater resources.

This may be done because either manufacturers fear difficulties when trading their produce or some organizations do not want to make a clean breast what appears to be negligence. For these reasons, this book will firstly introduce in boxes, some definitions of terms that will be used throughout the entire report and will secondly analyze existing information from different sources using for the given reasons, non-standardized methods of reporting. Despite these limitations, the descriptions presented are useful to provide an idea of the wastewater treating method and the extent use of agro-industrial wastewater, extract and sludge for irrigation and agricultural practices.

In the greatest parts of Ethiopia, the water required for crop production is provided mostly by rainfall. Nowadays; however, the efficiency and sufficiency of rainfall, even in high rainfall receiving areas, is interrupted by its erratic occurrence, uneven distribution, poor soil, and water management. There is also a scarcity of water during dry seasons. As a result, it becomes an obligation to establish water conservation and irrigation systems to have it in Ethiopia. To achieve this, farmer participation and coordination of the efforts of different institutions is highly considered. According to the United Nations Population Fund [6] and Central Statistical Agency of Ethiopia [7] the world and Ethiopian population surpassed 7 billion and 73 million, respectively. Hence, it is becoming very imperative to produce more than once per year apart from increasing yield per unit area to feed the increasing population.

When we were few in population and drought was not as frequent as it is now, rain fed agriculture could and did feed our population [8]. But now rain fed cultivation alone in the highlands will no longer support us, even in good years. So using our water resources in the form of irrigation is crucial to an extra rain fed cultivation, ensure sustainable agriculture and coop within the periods of inadequate rain fall. Among the mandates of Kulumsa Agricultural Research Center (KARC), includes generating of improved technologies along with the provision of preliminary materials for technology multiplications (breeder and pre-basic seeds) are the most important once.

So far the technology generation process was very lengthy; because of its entirely dependent on rain fed agriculture. Following the current trait, shortening of technology release-period has been found very important. Besides, the gap between demand and supply of new improved technologies need to be bridged. In line with the fulfillment of its mandate, the KARC has already launched a huge irrigation scheme development with financial support from the EAAPP by making use of wastewater discharge which released out from the nearby Asella Malt Factory. Previously, it was released without any care and creating health, social and environmental problems to the surrounding environment, and with its existing natural water supply, which was diverted few years ago to the research center as an additional water resource towards increasing the capacity of the KARC's formerly installed two reservoir ponds and the newly constructed one additional reservoir pond.

Based on the results of a quality test conducted at the National Soil Testing Center, the barley washed-out wastewater has been proved environmentally friendly for agricultural purposes. Hence, shortening of the technology generation process and significant contribution towards the supply of starting materials for technology multiplication are possible. Land application of wastewater, sludge and extract is a widespread practice with a long tradition in many countries around the world. With the above apprehensions bearing in mind, this pilot review study has been carried out with a pursuit to create the treated wastewater irrigation project all with depended on the malt-bailey washed out wastewater of the Asella malt factory and the existing freshwater supply of our research center, which was diverted to Kulumsa Agricultural Research Center (KARC), before ancient years to use it as an extra water capacity for the then water resource and it can also have a significant function in ever-rising the potential of the KARC's formerly installed and the newly constructed ponds.

Body of Discussion

Reusing of Treated Industrial-Wastewater for Irrigating Agriculture

In rural and peri-urban areas of most developing countries, the use of sewage and wastewater for irrigation is a common practice. Wastewater is often the only source of water for irrigation in these areas. Even in areas where other water sources exist, small farmers often prefer wastewater because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizers. Concern for human health and the environment are the most important constraints in the reuse of wastewater. While the risks do need to be carefully considered, the importance of this practice for the livelihoods of countless smallholders must also be taken into account. The aim of IWMI research on wastewater irrigation is to maximize the benefits to the poor who depend on the resource while minimizing the risks.

Treated Wastewater Irrigation Offer an Extra Earnings for Farmers

Many wastewater irrigators are not landowning farmers, but landless people that rent small plots to produce income-generating crops such as vegetables that thrive when watered with nutrient-rich sewage. Across Asia, Africa and Latin America these wastewater micro-economies support countless poor people. Stopping or over-regulating these practices could remove the only income many landless people have.

The Preeminent Opportunities of Wastewater Management

Affluent countries regard wastewater treatment as vital to protect human health and prevent the contamination of lakes and rivers. But for most developing countries this solution is prohibitively expensive. In this case, applying wastewater to agricultural lands is a more economical alternative and more ecologically sound than uncontrolled dumping of municipal and industrial effluents into lakes and streams.

The Safer Extensive Farming Practice of Wastewater Irrigation

Obviously, the short-term benefits of wastewater irrigation could be offset by the health and environmental impacts. The first step is to scientifically evaluate these. Once the actual risks are clear, we can work to reduce them. This means, for example, finding affordable ways of monitoring the presence of harmful contaminants in wastewater, such as heavy metals that can accrue in soil and crops. It means looking at farming practices and crops grown to find ways of minimizing risks of infection for farmers and consumers. IWMI's research in Pakistan, Ghana, Vietnam and Mexico examine both positive and negative impacts of wastewater reuse for agriculture. This work will result in tools and concepts that can help policymakers and planners balance the needs of small farmers with the health of people and the environment.

2.5. The soil characteristics of the Kulumsa Agricultural Research Center's irrigation project area.

According to the study results of [9] the soil Physico-chemical characteristics of the project area are summarized here underneath:

Table 1. The Soil Characteristics of Kulumsa Agricultural Research Center

Physical properties					Chemical properties				
Soil Depth	Particle Size (%)			Soil Texture Class	Available P (ppm)	pH in water (1:2.5)	N %	OC %	OM %
	Sand	Silt	Clay						
0-30	27.46	24.22	48.32	Silty clay loam	2.574	6.69	0.11	1.88	3.25
Note: P=Phosphorus, pH=Potential Hydrogen, N=Nitrogen, OC= Organic Carbon, OM=Organic Matter									
Source: Anbessie D., Abebe M., and Dechassa H., (2020)									

The type of soils in Kulumsa Agricultural Research Center are known as, Haplic Alisols, Eutric Vertisols and Vertic Luvisols. About 83.07% of the soil type at Kulumsa Research Center is classified as Vertic Luvisols and about 10.06% of the soil type is classified as Eutric Vertisols and about 6.87% of the soil type is also classified as Haplic Alisols (Abayneh *et al.*, 2003). The soils are deep to very deep (>100 cm) and clayey in texture. The agro-climatic condition of the area is wet and receives the annual mean rainfall of 809.15 mm from March to September; however, the peak season is from July to August. The average annual maximum and minimum mean temperatures are 23.08 and 9.9°C, respectively (Jemal A. *et al.,* 2015). The pH of the soils ranges from 6.593 to 6.786 and subsurface soils have higher pH values than surface soils (Abayneh *et al.,* 2003). Kulumsa Research Center is located on very gently undulating topography with a gradient of 0 to 10% slope. In some places where the slope is very flat, flooding and water logging had still some effects. The soil moisture establishment can be classified as ustic and the soil temperature as Isothermic (Abayneh *et al.,* 2003).

Table 2. Some characteristics of countries using wastewater for irrigation

Use of wastewater for irrigation	Total number of countries	GDP per capita for 50% of the countries (in $US)	Sanitation coverage or 50% of the countries (in %)
Untreated	23	880 – 4800	15–65
Treated & untreated	20	1170 – 7800	41–91
Treated	20	4313 – 19800	87–100

Proper Usage of Agro-Industrial Wastewater for Irrigation

In the literature, there is no comprehensive global inventory of the extent of non-treated wastewater used for irrigation; actually, none exists even for treated wastewater. Based on information from the countries providing data on irrigated areas, it is estimated that more than 4–6 million hectares are irrigated with wastewater or polluted water [10, 3, 11]. A separate estimate indicates 20 million ha globally, an area that is nearly equivalent to 7% of the total irrigated land in the world [12].

In contrast, the area reported to be irrigated with treated wastewater amounts to only 10% of this value. In practice, due to the under-reporting of areas irrigated with polluted water, the difference may be much higher. Two decades ago, [13] estimated that the area using raw wastewater or polluted water was 3 million ha; recent data suggest an area six times larger. It cannot be determined whether this difference refers to a de facto increase in the area or only in available data, but both might be the case, given the increasing amounts of wastewater generated as well as urban food needs. The resulting agricultural activities are indeed most common in and around cities [14], but can also be seen in rural communities located downstream of where cities discharge, unless treatment or self-purification processes take place.

Much of this use is not intentional and is the consequence of water sources being polluted due to poor sanitation and waste-disposal practices in cities. [15] suggest from a survey across the developing world that wastewater without any significant treatment is used for irrigation purposes in four out of five cities. In terms of volume of wastewater used for various purposes, the quantity varies considerably from one country to another. The majority of this is reported to be used in developing countries, where 75 per cent of the world's irrigated land is located [16], with a small amount, even if not expected, being used in some developed countries [4].

In a new review integrating data from [4] and the 46 countries report the use of polluted water for irrigation purposes shows a clear increase in GDP and the percentage of improved sanitation from countries using untreated to treated wastewater. Countries with middle income are those using both types of water, indicating a transition between unplanned and uncontrolled reuse to planned and controlled reuse. Countries using only treated water for irrigation purposes have sanitation coverage of at least 87 per cent. Few studies have quantified the aggregate contribution of wastewater to food supply. In Pakistan, about 26 percent of national vegetable production is irrigated with wastewater [17], while in Hanoi, Vietnam, which is much wetter than Pakistan, about 80% of vegetable production is from urban and peri-urban areas irrigated with diluted wastewater (Lai, 2002). Across major cities in West Africa, between 50 and 90 per cent of vegetables consumed by urban dwellers are produced within or close to the city [18] where much of the water used for irrigation is polluted. The use of grey-water exclusively has not been extensively documented, partly because it tends to be mixed together with black water.

In cases where it is used as such, it is commonly an in-house practice, which makes it difficult to assess, but it is being popularized in the Middle East for irrigation purposes. In some States in the USA, grey-water use is permitted for household irrigation and state legislation and guidelines exist. Australia, which has major scarcity problems, commissioned studies on grey-water reuse but no comprehensive information is available. In countries where this is permitted, there are instances of grey-water use for toilet flushing after treatment.

Low- and middle-income countries such as India, Mali, Jordan, Palestine, South Africa, Nepal, Sri Lanka, Costa Rica and Malaysia are using grey-water for gardening and irrigation of non-edible crops such as fodder and olive trees [19]. In most cities of sub-Saharan Africa, grey-water is channeled into drains where it often gets mixed with storm-water, solid waste and extract from open defecation before it enters natural water bodies. As these drains or streams are often used for irrigation, it is difficult to distinguish between grey-water and wastewater use [20, 18, 2].

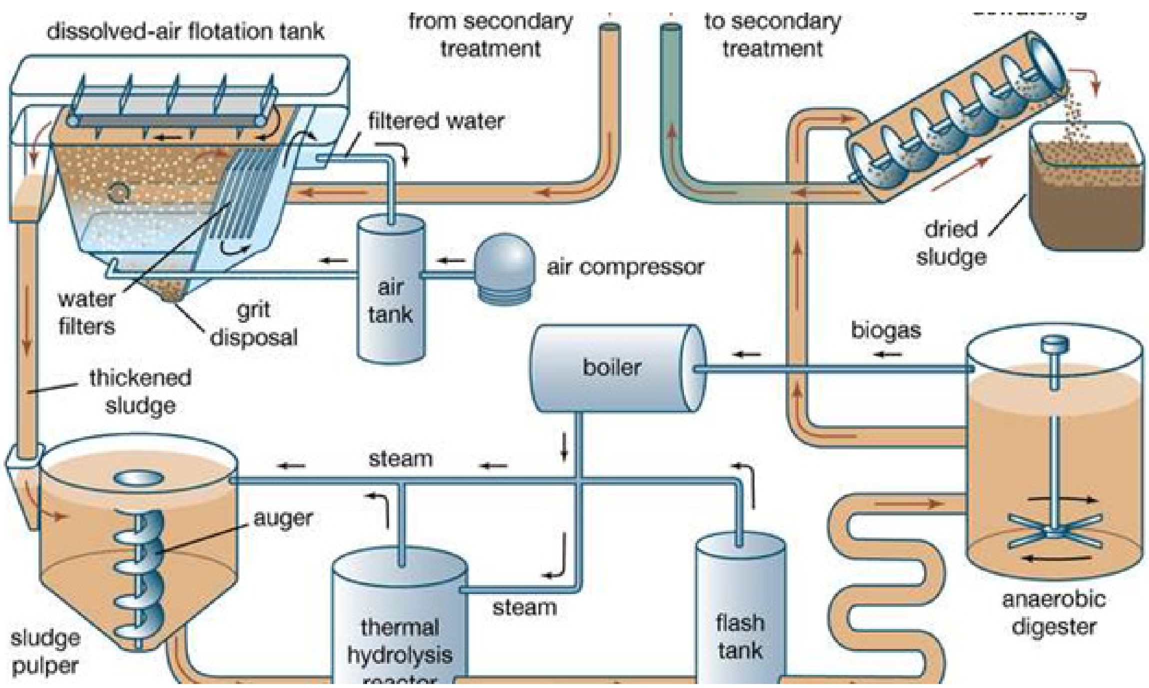
A recent survey in two Ghanaian cities showed that grey-water use for backyard irrigation is very low (International Water Management Institute) [21], despite the fact that grey-water and black-water have separate networks, and the proper use of grey-water could be promoted. The situation can be different in drier areas where tap water is precious and natural water sources rare. Jordan is piloting projects with a view to up-scaling grey-water use as, for example, in the Jerash Refugee Camp, where grey-water is separated and discharged from all houses into the environment through small ditches and open canals that serve farmers producing crops (WHOIDRC, 2006). India is also using partially treated grey-water for kitchen-garden irrigation and sanitation [22] and it seems that this practice is beginning to be widely applied in several regions.

The Productive and Destructive Effect of Fecal Sludge and Bio-Solids

The problem of fecal sludge management is compounded by the large number of on-site sanitation systems, such as latrines, unsewered public toilets or septic tanks, used by the majority of the population for disposal of black-water in densely populated cities. Fecal sludge collected from on-site sanitation installations is sometimes transported to treatment ponds but is more often dumped in depressions, streams or the ocean, or reused untreated on farmland, discharged in lakes or fish ponds or disposed of within the household compound. Assuming a per capita faecal sludge production of 1 liter/day [23], a truck-load of 5m3 dumped indiscriminately is equivalent to 5000 open defecations [24].

Sewage Sludge Treatment and Disposal Method

The residue that accumulates in sewage treatment plants is called sludge or biosolids. Sewage sludge is the solid, semisolid, or slurry residual material that is produced as a by-product of wastewater treatment processes. This residue is commonly classified as primary and secondary sludge.



Source: Encyclopedia Britannica, Inc. 2012

Figure 1: Hydrolysis Sludge-Sewage Wastewater Treatment and Disposal Systems

Primary sludge is generated from chemical precipitation, sedimentation, and other primary processes, whereas secondary sludge is the activated waste biomass resulting from biological treatments. Some sewage plants also receive septic tank solids from household on-site wastewater treatment systems. Quite often the sludge's are combined together for further treatment and disposal.

These practices represent a significant risk to public health and have a high disease impact on workers emptying the tanks and trucks, their families, the households living in the immediate area and on vulnerable populations in latrine-based cities [25]. In Ghana, Mali and Benin, farmers are known to bribe septic truck drivers to dump the faecal matter in their fields.

Fortunately, the practice poses little health risk to consumers where there is sufficient exposure to sun and a long dry season which result in pathogen die-off, or where the crops grown are cereals [26, 27] . Systems where the faecal sludge is first dried and then mixed with solid waste for co-composting have been reported from experimental stations in Ghana and Nigeria.

Settled sludge from sludge treatment ponds has also been used to 'blend' compost from solid waste, as observed in Accra, Ghana [28, 24]. Use of extract is seldom made public, but is known to have been practiced for centuries in Asia [25], in particular in China (UNHSP, 2008) and Vietnam [29,30]. in both agriculture and aquaculture. In China, use of extract in agriculture continues to be common and this practice has led to a strong economic linkage of urban dwellers and urban farmers. Thus, vegetables grown on extract-conditioned soils yield higher sales prices.

With increasing efforts to introduce urine-separating toilets, the first data on urine reuse has emerged. In both developed and developing countries, sludge disposal is an issue growing in line with the increase in the volume of wastewater treated. Historically, sewage sludge has been considered to be waste that is to be disposed of at the least possible cost (UNHSP, 2008). As a result, it has traditionally been dumped in landfills, holes, any unoccupied surface and drainage systems [31]. However, fecal sludge, extract and Bio-solids are increasingly being applied on land in low and middle-income countries due to the high cost of modern landfills that meet all environmental requirements, the difficulty of finding suitable sites for landfills even in developed countries and the benefit of recycling plant nutrients and enhancing soil characteristics.

Their main use worldwide greater than 60 percent is to fertilize agricultural fields or green areas. This practice solves a problem for municipalities, helps farmers to decrease their organic and mineral fertilizer costs and preserves or improves soil fertility. Another important use of sludge is to improve degraded soils at mining sites, construction sites and other disturbed areas (UNHSP, 2008). Fecal sludge (FS) that is collected from septic tanks poses management challenges in urban areas of developing countries. Currently, FS is dumped into the urban and peri-urban environment, posing great risks to the soil, surface water and groundwater quality. FS treatment technology usually consists of the following.

a) Primary treatment for the separation of the solid and liquid parts, and
b) Sludge treatment, which is the final stage of treatment that is generated from the primary treatment.

A decision matrix was prepared on the basis of primary and sludge treatment technological options with respect to land requirement, energy requirement, skill requirement, and capital cost operating cost and groundwater level. These parameters strongly influence the decision-making about the selection of the FS treatment technology. The selection of a FS treatment technology for a city also depends on the local conditions and priorities of the region with regard to sanitation such as population coverage, environmental and health benefits, elimination of open defecation, etc. Techno economic feasibility of different combinations of primary and sludge treatment technologies was conducted to evaluate its viability. The analysis was conducted across different classes of cities with varying population size.

The combination of primary treatment technologies with solar sludge oven emerged to be the most economically viable options for FS treatments across different population size in developing countries. On the bases of this operation program, the total wastewater discharge by the factory predicted to be about 415m3 within 36hr's.

This discontinuous wastewater flows out of the factory compound via the main get to be conveying by an open earth-ditch along the roadsides. Finally, the Wastewater ultimately released by the factory flows into a downstream River named Kulumsa.

Figure 2: The KARC’s previous structure of irrigation water reservoir ponds.

Under the conditions applied in this project, the reuse of treated agro-industrial wastewater for irrigation can be considered as an effective way to cope with agricultural water shortage in the Mediterranean area. It is useful in the discussion to differentiate between unplanned use of wastewater resultant from deprived sanitation, and planned use which tries to address matters such as economic or physical water scarcity.

Figure 3: The current map structure of irrigation water reservoir ponds at Kulumsa Research Center

Opportunities and Benefits of Water Reuse

In water-scarce countries and regions, the recycling of wastewater provides one opportunity to substitute limited freshwater resources with reclaimed water for purposes that do not require drinking water quality. Wastewater, which is usually continuous throughout the year, can provide a reliable water source while freshwater availability may be characterized by high seasonal variations or extreme events. Since these patterns are becoming more likely with climate change, interest has grown in water reuse opportunities and not only in arid countries. Potential water reuse applications include agricultural and landscape irrigation, industrial reuse, and groundwater recharge, applications for firefighting, and street cleaning, as well as recreational and ecological uses [32, 33]. In Australia, the introduction of water reuse has facilitated an increase in agricultural production, despite the limited availability of freshwater resources [32].

In Tunisia, where wastewater reuse is a well-established practice, reclaimed water for agricultural purposes consists of about 20% of wastewater effluents, promoted by the state in order to save freshwater for the drinking water supply and to protect receiving waters [34, 35]. Irrigation with reclaimed water may also have benefits in terms of providing nutrients to crops, thus potentially reducing the need for synthetic fertilizers in agriculture [36]. However, ensuring a balance between adequate wastewater treatments and adapting nutrient loads in reclaimed water to specific crop requirements and their seasonal variations can be challenging. Otherwise, excessive nutrients may cause plant damage and leach into groundwater. A decision matrix was prepared on the basis of primary and sludge treatment technological options with respect to land requirement, energy requirement, and skill requirement, capital cost, operating cost and groundwater level. These parameters strongly influence the decision-making about the selection of the FS treatment technology. The combination of primary treatment technologies with solar sludge oven emerged to be the most economically viable options for FS treatments across different population size in developing countries.

Constraints of Faecal Sludge Treatment

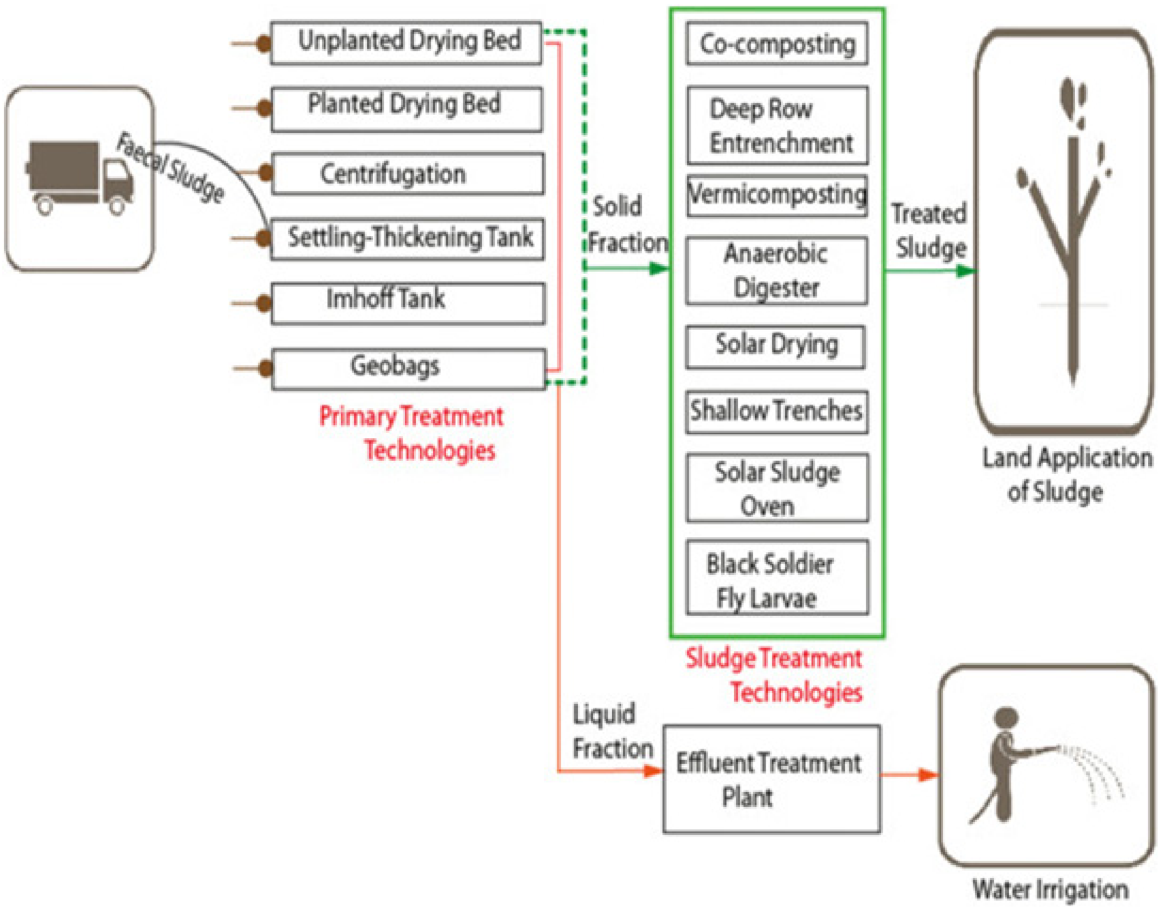
Treatment in Developing Countries Conversion of FS to valuable products without any foul odour, flies and pathogen transmission is a challenging task in developing countries. The choice of FS treatment methodology primarily depends on the sludge characteristics and their reuse option [e.g., land application, biogas production or landfilling [37]. Sludge characteristics vary significantly depending on the location, water content and storage. For example, ammonium concentration in FS can vary from 300–3,000 mg/L, while 60,000 Helminth Eggs can be present per liter of FS [38]. The FS characteristic determines the appropriate type of treatment and reuse. The wide variety of FS characteristics requires considering suitable options for primary treatment.

Primary treatment is used for dewatering or solid–liquid separation or biochemical stabilization of FS. Technologies for dewatering of FS have been reported previously [39]. Dewatered sludge with low moisture content reduces transport loads and is easier to handle. Dewatering is also necessary prior to composting and landfilling to reduce the leachate percolation to the groundwater. The choice of FS treatment methodology also depends on the practice used for FSM. In developing countries, households mostly use septic tanks, twin pits and manual emptying for FSM. The sludge collected from the septic tank and twin pit is biochemically more stable due to longer storage periods as the sludge is emptied from the septic tank and twin pits in 2–3 years.

The Destructive Impact of Wastewater Discharge and Remedial Measures

The expected negative impacts of the AMF discharges are being observed on public health affects due to its stinky smell when the discharge is going to be stored in the reservoir, mild stinky smell is expected in its vicinity. As a sustainable solution, experimentation will soon be launched to make use of effective microorganism, which can remove or minimize the unwanted smell. Studies have revealed that these microorganisms have been found very effective with respect to avoiding such smells.

If the wastewater is not properly treated, then the atmosphere and anthropological well-being can be harmfully impacted. These impacts can include harm to fish and wildlife populations, oxygen depletion, beach closures and other restrictions on recreational water use, restrictions on fish and shellfish harvesting and contamination of drinking water. Some examples of pollutants that can be found in wastewater and the potentially harmful effects these substances can have on ecosystems and human health:



Source: Shubhra Singh, Riya Rachel Mohan, Sujaya Rathi1 and N. Janardhana Raju, CSTEP, No 18 & 19, [40].

Figure 3: Overview technology options of faecal sludge management for developing countries

The selection of a FS treatment technology for a city also depends on the local conditions and priorities of the region with regard to sanitation such as population coverage, environmental and health benefits, elimination of open defecation, etc. The analysis was conducted across different classes of cities with varying population size.

The Essential Uses of Agro-Industrial Wastewater for Agriculture

In developing countries, the limited financial and physical resources to treat water, the socio- economic situation and the context of urbanization create the conditions for unplanned and uncontrolled wastewater use.

A study commissioned by the Comprehensive Assessment of Water Management in Agriculture showed that across 53 cities in the developing world the main drivers of wastewater use in irrigated agriculture are a combination of the following aspects [15]. Limited capacities of cities to treat their wastewater, causing pollution of soils, water bodies and traditional irrigation water sources;

- Lack of alternative cheaper, similarly reliable, available or safer water sources in the physical environment.
- Urban food demand and market incentives favoring food production in the proximity of cities, where water sources are usually polluted.

In addition, [41] pointed to the influence of socio-economic factors at the household level, like poverty and low education in developing countries, where lack of job opportunities and a limited awareness for health risks coexist. In such circumstances, wastewater reuse can represent a promising opportunity for cash crop production or to improve food supply. Once wastewater reuse is in place and its advantages have been gauged by the population, it is difficult to alter behavior especially if changes have an associated cost or are linked to historical water rights. This may be compounded by reduced availability of freshwater resources, be it for economic or physical reasons.

The nutrient value of raw wastewater and sludge is inherently recognized by farmers, which is also a factor driving their use. In contrast, in more developed countries, water reuse and recycling are increasingly seen as a means to respond to physical water scarcity including climate change and drought management, water reallocations from agriculture to other uses and also as an economic response to costly inter-basin transfers.

An additional factor influencing recycling is the stringent environmental standards, which make land application of wastewater and sludge both unavoidable and economically feasible. Drivers of agricultural reuse of sludge and extract are linked more to disposal issues than to the intention to reclaim components of them. However, many farmers consider them to be a valuable resource similar to farmyard manure.

This beneficial use is increasingly gaining momentum, driven by the intention of closing nutrient loops to ensure that nutrients are returned to agricultural land to improve soil fertility. One of the main differences observed between the use of wastewater and that of sludge and extract is a greater acceptance of wastewater use, as sludge and extract have been historically considered, in most cultures, to be not only noxious but also an object of shame 8y

Typology of Agro-Industrial Wastewater Uses

Various authors have attempted to provide typologies for wastewater recycling and use. But none of these has been taken up universally or been standardized. However, in describing wastewater reuse, the terms direct, indirect, planned and unplanned recur frequently. These are explained here with examples:

- Direct use of untreated wastewater refers to the use of raw wastewater from a sewage outlet, directly disposed of on land where it is used for crop production.
- Indirect use of untreated wastewater refers to the abstraction of usually diluted wastewater (or polluted stream water) for irrigation. This is common downstream of urban centers where treatment facilities are limited. Farmers might or might not be aware of the water-quality challenge.
- Direct use of treated wastewater refers to the use of reclaimed water that has been transported from the point of treatment or production to the point of use without an intervening discharge to waters.

Planned water reuse refers to the conscious and controlled use of wastewater either raw direct or diluted (indirect). However, most indirect use happens without planning, at least initially, for using low quality water. Direct use often takes place in dry climates where water sources are scarce. Treated, untreated or partially treated wastewater is used directly for irrigation without being mixed or diluted.

Direct use of treated wastewater is most common as a planned process in developed countries including some larger parts of the Middle East and North African region, but can also take place unplanned, for example in dry seasons, when streams only carry wastewater, as is the case for the Musi River in Hyderabad, India. However, the use of diluted wastewater for irrigation indirect use is significantly more frequent than direct use and occurs even more in wetter climates. In this situation, untreated or partially/insufficiently treated wastewater from urban areas is discharged into drains, small streams and other tributaries of larger water bodies where it is usually mixed with storm water and freshwater, resulting in diluted wastewater or polluted surface water.

It is then used by farmers, most of whom are traditional users of these water sources. Lack of adequate sanitation and waste-disposal infrastructure in cities is one of the direct causes of such pollution and use [4, 15]. This situation is not limited to low-income countries that have no capacity to collect and treat wastewater comprehensively, but occurs also in fast-growing economies like China, Brazil, and some countries of the Middle East and North Africa region.

For example, despite massive investments in wastewater treatment, the city of Beijing is only able to treat about half of the wastewater generated and untreated wastewater is discharged into waterways used downstream by farmers [42]. Also, in Lebanon and Palestine most of the wastewater collected from sewered localities is discharged into nearby rivers, wadis, and the sea, and on open land from where it infiltrates the ground with little or no treatment [43]. In spite of strict European Union (EU) regulations, untreated wastewater is discharged into rivers which are used for irrigation in some countries such as Spain, Italy and Portugal, especially in summer when there is little or no river flow (Juanico and Salgot, 2008).

However, this practice is being reduced due to efforts made by countries to increase the level of wastewater treatment to meet EU legislation. In Turkey, an enormous amount of domestic wastewater is discharged into rivers and used for irrigation because of insufficient sewerage facilities and lack of satisfactory treatment [10]. Some areas, irrigation infrastructure originally built to transport freshwater, surface or groundwater is now used for wastewater during certain periods.

The Engineering Works Done to Divert and Harvest the Wastewater

The engineering works done to divert and harvest the wastewater incudes canals, manholes, settling basis, mixing chambers, ponds, pump house, sprinkler and drip irrigations systems, etc. Pictures showing the existing structures on the ground have been showed hereunder and, their purpose described well. Wastewater engineering is a profession that is extremely experiment-based, and therefore it has always had the need to develop and standardise methods. This seemingly simple activity is strongly hampered by two factors, namely:

a) Wastewater engineering is a typical interdisciplinary activity where chemical engineers, civil engineers, microbiologists and chemists interact to develop and understand the processes; the challenge here is to integrate methods and approaches from these disciplines, and,

(b) In addition, wastewater and its treatment processes are by their nature difficult to define with exactitude. It is for instance virtually impossible to measure all the individual compounds in the wastewater itself. Identifying all the relevant microorganisms in the processes has long been impossible and is still a complicated challenge.

The Importance of Wastewater Treatment

The major aim of wastewater treatment is to remove as much of the suspended solids as possible before the remaining water, called effluent, is discharged back to the environment. As solid material decays, it uses up oxygen, which is needed by the plants and animals living in the water. Primary treatment" removes about 60 percent of suspended solids from wastewater. This treatment also involves aerating or stirring up the wastewater, to put oxygen back in. Secondary treatment removes more than 90 percent of suspended solids. Wastewater treatment is a process used to remove contaminants from wastewater and convert it into an effluent that can be returned to the water cycle.

Once returned to the water cycle, the effluent creates an acceptable impact on the environment or is reused for various purposes called water reclamation (Encyclopedia Britannica, 2020). The treatment process takes place in a wastewater treatment plant. There are several kinds of wastewater which are treated at the appropriate type of wastewater treatment plant. For domestic wastewater (also called municipal wastewater or sewage), the treatment plant is called a sewage treatment plant. For industrial wastewater, treatment either takes place in a separate industrial wastewater treatment plant, or in a sewage treatment plant (usually after some form of pre-treatment). Further types of wastewater treatment plants include agricultural wastewater treatment plants and leachate treatment plants.

Processes commonly used include phase separation such as sedimentation, biological and chemical processes such as oxidation or polishing. The main by-product from wastewater treatment plants is a type of sludge which is usually treated in the same or another wastewater treatment plant (Metcalf & Eddy, Inc., 2003). Biogas can be another by-product if anaerobic treatment processes are used. Some wastewater may be highly treated and reused as reclaimed water. The main purpose of wastewater treatment is for the treated wastewater to be able to be disposed or reused safely. However, before it is treated, the options for disposal or reuse must be considered so the correct treatment process is used on the wastewater. The term "wastewater treatment" is in the literature often used to mean "sewage treatment". Strictly speaking, wastewater treatment is broader than sewage treatment. The pictures showing the KARC's existing structural feature on the ground have been presented and their purposes described as well hereunder (Figure 4).

Treated Wastewater Usage at Kulumsa Agricultural Research Center

The reusing of agro-industrial wastewater for irrigating agriculture is a large-scale irrigation project that launched ten years ago at Kulumsa Agricultural Research Center. The reusing of agro-industrial wastewater for irrigating agriculture is an issue of concern to relevant organizations accountable for keeping public comfort and eco-friendly quality. For various reasons, many irrigation organization in the country are still unable to implement comprehensive wastewater treatment programs. Thus in the near term, risk management and conditional solutions are needed to avoid and prevent different impacts from wastewater irrigation.

The present wastewater irrigation system in Kulumsa Agricultural Research Center relates to reusing of agro-industrial wastewater of Asella Malt Factory for irrigating agriculture, by developing the wastewater treatment system that removes biodegradable pungent smells, organic contaminants, over saturated nutrients, pathogens and the like from the wastewater discharges of residential homes, commercial businesses, industrial facilities, municipal facilities, agricultural facilities and the like. In order to protect the environment and promote public health, communities typically there is a need to make the wastewater treatment activities. The discharge of untreated wastewater is not suitable, since it gives rise to numerous environmental concerns, such as the pollution of surface and groundwater resources.

Untreated wastewater contains organic matter and nutrients that, if left untreated and not removed from the waste stream, can result in environmental pollution. Thus, when untreated wastewater is released into either aboveground bodies of water or subsurface drain fields, the level of dissolved oxygen in the receiving waters begins to deplete, which endangers the water bodies themselves, along with the resident plant and aquatic life.

Furthermore, in our country, where potable water is scarce, it is often desirable to recover as much reclaimable water as possible from wastewater, rather than disposing of both the wastewater and the contaminants. To treat and use wastewater, communities in highly populated areas commonly collect wastewater and transport it through a series of underground pipes to a large centralized wastewater mixing chamber. However, there are several problems associated with large, centralized treatment chamber.

Centralized wastewater treatment chamber is designed and rated for processing a specific flow rate of treated wastewater per hour, typically expressed as the rated capacity of the mixing chamber, and all treatment pump house have a paramount flow rate capacity. As a result, if a centralized treatment chamber receives more wastewater on a particular hour than what the mixing chamber was designed to handle, problems are encountered.

For example, when a mixing chamber receives larger-than-normal amounts of untreated raw wastewater, treatment performance decreases and partially treated or untreated wastewater is released into a body of water, such as a river, in order not to exceed the amount of wastewater the method of wastewater treatment for irrigation purposes was designed to handle.

As noted above, discharge of this untreated wastewater into the river will endanger and harms resident populations and aquatic life in the river. Untreated wastewater also contains a number of disease pathogens that are extremely harmful to humans. For instance, untreated wastewater is one of the most important causes of dysentery, which can be life threatening. Thus, if a significant amount of untreated wastewater is discharged into a river, that river will become unavailable for human consumption.

On the other hand, if the treatment plant processes the larger-than-normal amounts of untreated wastewater, instead of diverting a portion into a body of water, the influx of untreated wastewater would wash away the bacteria populations or biomass used by the mixing chamber to treat the untreated wastewater, which would disrupt the entire biological treatment process of the mixing chamber.

Further, as noted above, wastewater treatment is particularly needed in our areas with the above concerns bearing in mind. The irrigation development project has been generated based on the agro-industrial wastewater which comes out from Asella malt factory and with our existing wastewater source, which was diverted before long ago years to Kulumsa Agricultural Research Center aimed to use it as an additional water capacity for the then irrigation water resource and it can also has an important role in increasing the capability of the KARC's newly constructed ponds, and such large-scale treatment plants may not be available.

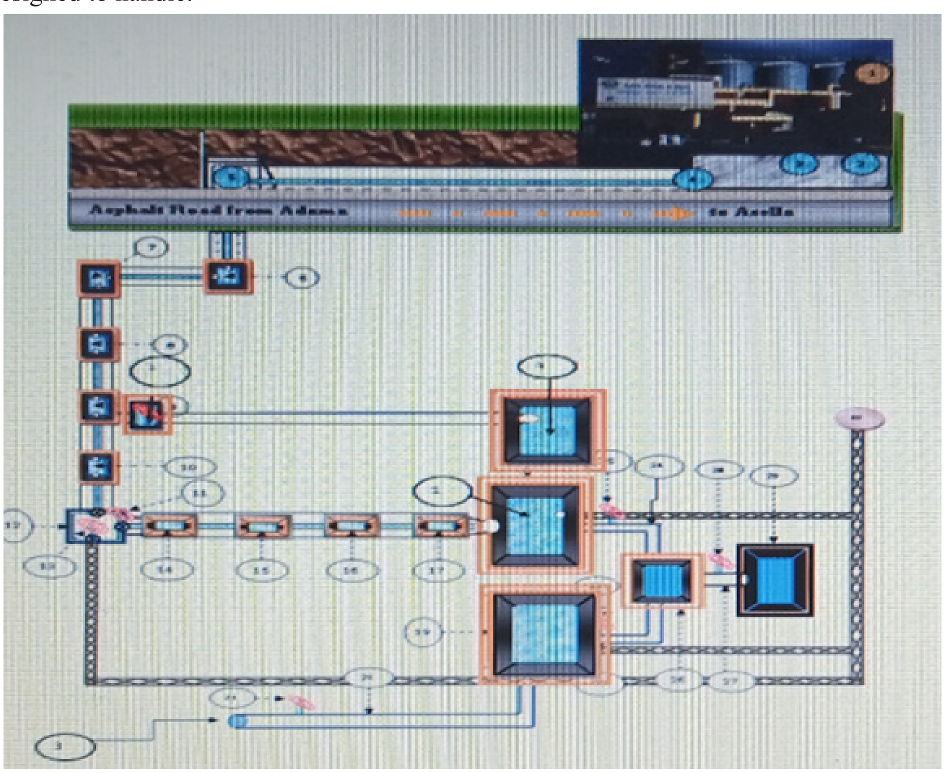


Figure 4: The KARC's Drawing Structure of the Wastewater Treatment Method for Irrigation Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., (2022).

The Brief Descriptions of The Ponds Project Structure

No. 1 is a source of the wastewater coming out from the Asella Malt Factory.

No. 2 and No. 3 are a 24 inch cemented concrete pipe-outlet for the wastewater of the Asella Malt Factory

No. 4 is the 24 inch cemented concrete pipe which takes out the wastewater from the No. 2 and No. 3 outlet pipes to go out through the diversion manhole of the No. 5.

No. 5 is a diversion manhole structure of the barley washed-out wastewater which coming out from the Asella Malt Factory to the Kulumsa Research Center through under the highway asphalt road from Addis Ababa to Asella town.

No. 6 to 6.10 are the manhole structures to use them for silt trapping purpose with the un inclusive distance of 100 meters amongst the open concrete ditch.

No. 11 is the get valve control system of the wastewater outlet canal to the silt trap basin structures.

No. 12 is a diversion manhole structure of the barley washed-out wastewater which coming out from the No. 10 manhole structure to the silt traps basin structures.

No. 13 is the get valve control system of the wastewater outlet canal to the avoidable drainage passage.

No. 14 to 17 are a silt trap basin structures for the purpose of minimizing the unnecessary sediments which can gradually accumulated in the ponds due to the long term effects.

No. 18 is a wastewater pond

No. 19 is a freshwater pond.

No. 20 is a 6 inch outlet pipe of the fresh water to the mixing chamber.

No. 21 is the get valve control system of the freshwater inlet pipe to freshwater pond.

No. 22 is a 6 inch freshwater outlet pipe to the mixing chamber

No. 23 is the get valve control of the freshwater outlet pipe to the mixing chamber

No. 24 is a 6 inch wastewater outlet pipe to the mixing chamber.

No. 25 is the get valve control of the wastewater outlet pipe to the mixing chamber

No. 26 is the mixing chamber.

No. 27 is the 12 inch outlet pipe of the treated wastewater from the mixing chamber to the pump house

No. 28 is the get valve control structure for the treated wastewater outlet pipe from the mixing chamber to pump house.

No. 29 is a pump house to be connected with the sprinkler structure on the farm lands.

No. 30 is the avoidable drainage outlet canal to the Shorima gorge.

No. 31 is a wastewater pond

No. 32 is a source of the freshwater

No. 33 is the get valve control of the wastewater outlet pipe to the reservoir pond

Wastewater is pumped into irrigation canals to supplement fresh irrigation water. For instance, in Vietnam, wastewater from Hanoi and other cities along the Red River Delta is pumped into irrigation canals at certain times of the year to supplement irrigation water (Trang et al., 2007a and b). However, at the tail end of irrigation systems or throughout in the dry season, wastewater may be the only water flowing in the canals in areas such as Haroonabad in Pakistan and Hyderabad in India [17, 44]. In Jordan, the As-Samra wastewater treatment plant mainly treats the domestic wastewater of the capital Amman. On its course to the Jordan Valley, the reclaimed water is mixed with surface run-off from wadis before it is temporarily stored in the country's largest reservoir, the King Talal Reservoir (KTR) (which has a storage capacity of 75 million cubic metres). The detention time of the water in the reservoir, which used to be about ten months, has been reduced to a few months with the increase of the wastewater flow. About 20km downstream from the KTR outlet, Zarqa Carriers divert part of the KTR water directly to fields in the Jordan Valley. The rest of the reclaimed water is finally released into the King Abdullah Canal which brings freshwater in the north to the Jordan Valley.

Productive and destructive effects of reusing wastewater and faecal sludge for irrigation

While the drivers for the use of wastewater, sludge and extract in agriculture differ between regions, their use – be it directly, indirectly, diluted or not – has a number of advantages along-side the well-known risks [13, 25, 5]. For centuries, wastewater has been improperly used in irrigating agriculture, presenting potential risks to public health and the environment. In the context of scientific development, and confronted by an increasing water crisis, wastewater reuse qualities concern because the practice helps decrease water use pressure and moderates water pollution. Thus, this book presents a literature review that addresses the effects, both constructive and destructive, of wastewater use in irrigating agriculture, highlighting the special effects on the soil environment.

The literature review discloses that, up to the 1990s, research studies encouraged the use of wastewater for irrigation resolutions from the wastewater treatment method, while proposing "end of pipe" derivative solutions. However, more recent research studies from 2012–2016 reveal that agricultural reuse significantly affects soil texture properties, while also causing possible alterations of the biomass and micro-biota. In addition, research in this period has been oriented to the quantitative evaluation of microbiological risk.

Productive Benefits of Reusing Treated Wastewater for Irrigation

As a consequence of the high global food demand, it is not surprising that, worldwide, the biggest user of wastewater (treated or not) is agriculture [4]. An important factor which makes wastewater valuable is that it is a reliable source of water, as it is available all year round, unlike pluvial precipitation or seasonal streams. Consequently, it permits higher crop yields, year-round production, and increases the range of crops that can be irrigated, particularly in arid but not limited to arid and semi-arid areas [3]. Studies conducted in Hubli-Dharwad showed that wastewater allowed farming to be done in the dry season when farmers could sell their produce at three to five times the kharif monsoon season prices [45]. Wastewater reliability also allows for multiple cultivation cycles and flexibility of crops planted [15].

Similar situations have been reported for Haroonabad, Pakistan; Accra, Ghana; and Dakar, Senegal [46, 47]. The increased productivity and related income/food supply gains allow farmers a more reliable livelihood with indirect benefits of using the income for education and improving health conditions. Where vegetables are the main commodity produced with wastewater, there can be a significant aggregate benefit for the society in terms of a more balanced diet. In the case of Accra, for example, more than 200,000 people eat vegetables produced with wastewater every day [48]. On the other hand, this is also the group potentially at risk as the possible adverse health effects to farmers and consumers are well established [25].

As part of the urban food-production systems, urban livestock contributes to cities' food security by providing meat and dairy products [49, 50]. In semi-arid countries, livestock production relies mainly on natural pasture, which is often limited or decreasing due to low precipitation. In Sahelian countries (i.e. Burkina Faso, Mali, Senegal), forage biodiversity has decreased over time and plant species with lower nutritive value and palatability are becoming predominant [49, 51] Food and Agriculture Organization of the United Nations (FAO), 2006; [52]. At the same time, however, the demand for dairy in cities is increasing with urbanization and changing diets. For example in Asian countries, the demand for dairy products is growing by a factor of 3.5 per year [53].

Reusing wastewater or faecal sludge for fodder production appears an important and comparatively low-risk avenue which can contribute to enhancing the resilience to climate changes and food insecurity especially of small and middle-sized cities in developing countries. Another well-established advantage of wastewater and sludge reuse is their nutrient content. Even when treated, wastewater recycles organic matter and a larger diversity of nutrients than any commercial fertilizer can provide. Bio-solids, sludge and extract in particular, provide numerous micronutrients such as cobalt, copper, iron, manganese, molybdenum and zinc, which are essential for optimal plant growth. It is estimated that 1000 cubic meters of municipal wastewater used to irrigate one hectare can contribute 16–62kg total nitrogen, 4–24kg phosphorus, 2–69kg potassium, 18–208kg calcium, 9–110kg magnesium, and 27–182kg sodium [2].

It therefore can reduce the demand for chemical fertilizers especially where the wastewater is not diluted, i.e. make crop nutrients more accessible to poor farmers. In the light of the global phosphorus crisis, extract and wastewater can be critical sources of phosphorus (Rosemarin, 2004). On the other hand, excessive concentrations of nitrogen in wastewater can lead to over-fertilization and cause excessive vegetative growth, delayed or uneven crop maturity and reduced quality [41, 2].

Excessive concentrations of some trace elements may also cause plant toxicity and sometimes become a health risk for crop consumers. Few studies have quantified the economic gains from nutrients in wastewater under actual field conditions. In Guanajuato, Mexico, the estimated saving arising from using wastewater to supply the required nitrogen and phosphorus for crops was US$135 per hectare [3]. A study comparing vegetable production using freshwater and untreated wastewater in Haroonabad, Pakistan, found that the gross margins were significantly higher for wastewater (US$150 per hectare), because farmers spent less on chemical fertilizer and achieved higher yields [54]. In a cost–benefit analysis of grey-water reuse systems constructed in residential schools in India, the internal and external benefits far outweighed the costs [55].

Although studies conducted to quantify economic returns are still few and lack a uniform methodological approach, they consistently report significant gains among farmers with access to wastewater. The annual income reported in such studies performed in India, Ghana, Senegal, Kenya and Mexico varied from US$420 to $2800 per hectare per year [3]. According to studies in Ghana, the greatest factor influencing farmers' profits is not so much the yield obtained, but the ability to produce crops that are in high demand and low supply, at the right time, the result being that they can be consistently sold at above average.

The profitability of the business is also reflected in farmers' decisions to pay more for, especially nutrient-rich wastewater than normal water. In Quetta, Pakistan, farmers paid 2.5 times more for wastewater than for freshwater [17]. While farmers and their families are direct beneficiaries, there are also indirect beneficiaries along the supply chain including farm laborers, transporters, vendors, processors, input suppliers and consumers [56]. With low investments and quick returns, this practice is lucrative and enables many farmers to leap over the poverty line [57]. In many West African countries, it is especially attractive to poor migrants looking for jobs in the city [5]. The land application of wastewater, sludge and extract for agricultural use constitutes a low-cost disposal method and a land-treatment system that uses the soil to attenuate contaminants.

If carried out under controlled conditions, it can also be safe. Wastewater use can also recharge aquifers through infiltration or reduce the impact on surface-water bodies, as wastewater is 'treated' in the vadose before reaching them [41]. Several wastewater constituents are subject to processes that remove them or significantly reduce their concentration. Reduced costs to society are also noteworthy, in view of reducing the use of fossil fuels to produce fertilizer.

3.8. Destructive drawbacks of using wastewater for irrigation

Among the disadvantages of using untreated or partially treated wastewater, sludge or extract, the most obvious are the health risks from pathogens. These have been discussed extensively elsewhere [25] and are also the subject of several chapters in this book. Some references will be provided here in order to give an idea of the magnitude of the problem. Firstly, it should be stated that diseases are linked to the nature of the pathogen in the wastewater and thus vary locally following the local public-health pattern.

Secondly, risks are not limited to farmers, but can be observed in four groups: agricultural workers and their families; crop handlers; consumers of crops or meat and milk coming from cattle grazing on polluted fields; and those living on or near the areas where wastewater, sludge or extract is used. Within these groups the most vulnerable sections of the population are children and the elderly. Thirdly, observed responses may vary considerably between developing and developed countries. This is because pathogen distributions and concentrations, to which these groups are exposed, are very different, as are the living conditions and the level of resistance to disease between developing and developed countries [58]. Furthermore, the statistics on food safety are unreliable because laboratory standards are so low in most developing countries.

Pathogens contaminate crops mainly via direct contact, though some cases of uptake by plants have been recorded [59]. Beside pathogens, wastewater and sludge can also be a source of high levels of heavy metals and organic toxic compounds [59, 60]. Contamination can occur, in the case of metals and some organic chemicals, through absorption from the soil, which strongly depends on the location that possible contamination sources, the environmental conditions particularly the soil, bio-availability in the case of some contaminants, type of plant and agricultural practices quantity of water applied and irrigation method (Jiménez, 2006).

There is relatively good knowledge concerning the allowable amounts of heavy metals that crops and soil can be exposed to when wastewater, sludge or bio-solids are applied to soil (Page and Chang, 1994; UNHSP, 2008; WHO, 2006). Moreover, for both developed and developing countries, the content of heavy metals in wastewater, extract and sludge from domestic sources is generally low enough to allow their use for crop fertilization (Jiménez and Wang, 2006; UNHSP, 2008; WHO, 2006). However, there are always cases where care has to be taken, for example, close to tanneries or mining areas [60]. The risk from organic components derived via wastewater is in general much lower than via direct pesticide application. In comparison with pathogenic health risks, pesticide levels on vegetables, even if elevated, were considered to be of secondary importance in the context of a developing country [14]. As described above, the use of wastewater, bio-solids and extract implies benefits but also risks.

Frequently, experts recommend simply banning this unsafe practice and 'properly' treating wastewater, sludge and extract. Such recommendations, besides being nearly impossible to implement in most developing countries for both economic and social reasons, would also result in the removal of components from these agro-industrial waste products that are not acting as pollutants but, conversely, are beneficial.

Therefore, in practice, there has to be a trade-off between the advantages and disadvantages and the best solution for each situation should be sought, even if this is considered unconventional, especially from a developed country perspective. From a technical point of view, the solution will basically consist of finding a way to supply soils and crops with water, nutrients and organic matter. This should take advantage of the assimilation capacity of the soil, so that pathogens or heavy metals do not cause harm, while putting in place additional measures to deliver safe food to consumers. These and other alternative options for health-risk reduction are supported by the Guidelines of WHO (2006) where conventional wastewater treatment fails for whatever reason.

3.9. Providing treated wastewater to meet quality irrigation water

Policies to control the unplanned reuse of wastewater where it is an ongoing practice are not only hard to implement but are even difficult to develop [61] because governments are faced with the trade-off between public-health protection and the ethical question of whether to prevent wastewater farmers from cultivating with the only source of water that is accessible to them [62].

The WHO, to assist in this decision-making process, has in recent years been giving consideration both to the limitations faced by developing countries in providing sufficient wastewater treatment to meet water-quality standards and the increasingly important livelihood dimension of wastewater use. This is reflected in the 2006 WHO Guidelines. If a government concludes that the practice must be stopped, then it has to put in place a complex process for control, with few successful examples in practice.

In almost all countries legislation exists, dating back several years or decades and referring directly or indirectly to the use of polluted water or wastewater for irrigation, which is always forbidden. Many countries have irrigation water-quality guidelines, but they do not always consider microbiological standards, and where wastewater use is permitted, the legislation requires that certain quality conditions are met. Such conditions usually follow the previous WHO Guidelines (1989) which recommended water-quality thresholds. Such regulations are not followed in practice for the many reasons mentioned above. A further factor is that wastewater irrigation usually takes place outside the officially recognized formal irrigation sector.

As a result, most governments ignore the situation or have no other means than to adopt a laissez-faire attitude (Drechsel et al., 2006). Joint efforts by WHO, FAO and United Nations Environment Program (UNEP) to respond to this global situation, and to encourage resource recovery, resulted in an enforceable and achievable regulatory framework to support worldwide the reuse of wastewater, grey-water and extract in agriculture and aquaculture [4].

These new Guidelines build on previous ones but are in their 2006 version much more supportive of the difficult sanitation conditions in most developing countries and have suggested a multiple-barrier approach for the long-term achievement of a universal health-based target. Furthermore, World Health Organization suggests local adaptation of the Guidelines with incremental achievements towards this target.

This flexibility means that authorities require support to understand and apply the new approach. The previous WHO Guidelines (1989) are often considered more straightforward, especially for countries that already have comprehensive wastewater collection and treatment in place. The resulting bias towards countries at the lower part of the sanitation ladder caused discomfort among those countries further up which have few problems in enforcing and monitoring crop or water-quality thresholds. These countries prefer to use, for example, standards similar to the California [63]. Such fixed standards are indeed most useful where they can actually be met by treatment, and wastewater use is a planned and controlled activity.

However, they are difficult to apply where treatment is rudimentary or lacking and when thousands of farmers already use polluted water sources because they have no alternative. Here, different strategies for health-risk reduction are needed. Similar regulations based on local needs and capabilities had been developed before the 2006 WHO Guidelines were released, e.g. in Australia [64, 65]. The advantage of the WHO Guidelines is that all the developing countries that have ignored previous guidelines, because the water-quality thresholds were too high, are now challenged to control the health risks as far as possible, rather than continuing to disregard the problem. The same applies to extract management which the WHO (2006) is also addressing.

Treated and Untreated Agro-Industrial Wastewater Sludge

Sludge management is mostly an issue for developed countries where wastewater treatment facilities allow sludge generation, separation, storage, transport and reuse. Considerable experience concerning the development of policies and regulations to promote the beneficial use of municipal sludge and bio-solids in soil exists in the EU and the USA. These regions have comprehensively analyzed the risks and benefits of the different use and disposal options. Many other countries have built their understanding and policies from this foundation of knowledge and experience, but integrate local needs and conditions into their policies, laws and regulations.

In general, the USA has adopted the concept of risk assessment in their environmental regulations contained in the 40 CFR Part 503 sludge regulation dating from the early 1990s. The approach takes maximum advantage of the soil's capacity to assimilate, attenuate and detoxify pollutants. Land application guidelines based on this approach set the maximum permissible pollutant loading and provide users with the flexibility to develop suitable management practices for using sewage sludge [66]. In contrast, the EU has adopted a precautionary or a no-net-degradation approach (UN-HSP, 2008). This approach prevents pollutant accumulation into bio-solids-receiving soils. As a result of this, the EU is well ahead of the USA in researching and phasing out chemicals of concern in personal care and commercial products, resulting in more costly control programs. Both approaches address pathogen reduction, the potential for accumulation of persistent pollutants in soils (heavy metals and persistent chemicals) and the application of appropriate amounts of nutrients.

One notable difference is that the EU Directive has stringent upper limits for pollutants and generally limits rates of applications of bio-solids to lower amounts than are allowed in USA. The cost of implementation of the directive is also higher, as wastewater treatment plants need to employ advanced wastewater treatment technologies to minimize the pollutant levels in the reclaimed wastewater and sewage sludge.

Regulatory structures in other countries that may not have the same level of resources available for wastewater sludge management are less precautionary. Balancing the need for strong regulations and enforcement with what is practical and achievable is the challenge. [67], for example, has pointed out that in South Africa an initial set of bio-solids management regulations that were consistent with some of the stricter regulations in Europe made management of wastewater sludge nearly impossible. Newer, more appropriate regulations are now helping move the country's wastewater sludge management programs towards higher levels of recycling and greater sustainability.

Examples of sludge management policies implemented in developing countries are still rare as the existence of properly functioning wastewater treatment plants is still an evolving phenomenon. One notable example occurs in the state of Paraná in Brazil where practical, successful, full-scale programs can be found [68]. In Tunisia, standards have been established for maximum allowable concentrations of chemical and biological components in soil and sewage sludge. Pollutant concentration limits for land application of sewage sludge were derived from the existing regulations, while specific management practices for land application and disposal of sewage sludge have been included in the national standards.

Water Scarcity and Wastewater Reuse in Irrigating Agriculture

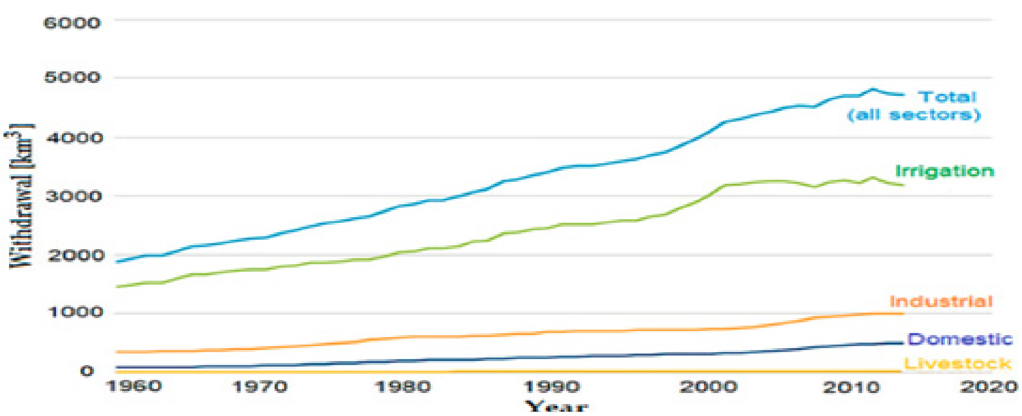
Taking into account the development of different agro-industries and human activities that contribute to the increase in climate change has become a reality that humanity faces every day. Climate change has significant undesirable effects on the quality and availability of water resources, food security and human health all over the world. Reliable with the global panel on Climate Change, in 2017, universal warming due to human activities reached an average of 10C above the pre-industrial levels [69]. By 2100, worldwide mean temperature could rise by 3.50C compared to the same period mentioned above [70]. with regional average variations of global temperatures between 1.4–5.8 0C [71].

It is predicted that climate change will account for about 20% of the global expansion in water scarcity Food and Agriculture Organization of the United Nations (FAO). (Food and Agriculture Organization of the United Nations (FAO) Ethiopia 2020), and this would affect the development and functioning of communities worldwide, both in social and economic terms. Earth contains approximately 1351 million km3 of water [72], of which only 3% is available freshwater resources suitable for drinking and irrigation. In the ideal situation when all available water on Earth would have been evenly distributed to a uniformly distributed population, a report by FAO mentions that each person would have had access to 5000–6000 m3 of freshwater/year. Since experts claim that people experience water scarcity below a threshold of 1700m3 /person, the ideal situation would have meant access to abundant freshwater resources for each person. In reality, however, neither freshwater resources nor the population is evenly distributed globally. The scarcity of freshwater resources is predisposed, among others, by the growth of population, urbanization, consumption per person, water pollution and climate change. Water scarcity is a significant indicator of health, and an issue of poverty, which mostly disturbs the people in rural areas, where high inhabitant's densities are prevalent [73].

A presumed 1.2 billion people live in river basins facing physical water scarcity, and another 1.6 billion live in water-deficient areas, where affordable water supply works are not available Food and Agriculture Organization of the United Nations (FAO 2020). The intensity of water scarcity, either in a region or at the country level, is assessed as the water stress index, which is estimated as the ratio between the annual water withdrawal from ground and surface water to the total renewable freshwater resources [74].

Worldwide, 40% of the total land area is arid, semi-arid and dry sub-humid. Half of the European countries are facing water stress, as stated by [75], No. 4, and a survey by [76]. classified the Member States into four categories of risk according to the water stress index, highlighting that about 10% of the European territory and 14% of the population were subjected to water scarcity.

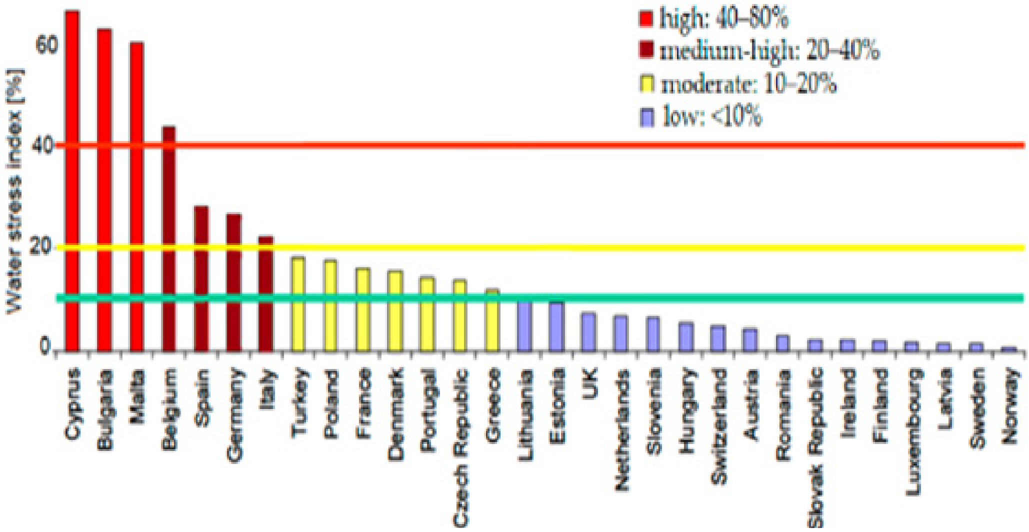
A report by (FAO 2018) enlightens that a country experiences water stress when it extracts over 25% of its renewable freshwater resources, physical water scarcity occurs at over 60% extractions and severe physical water scarcity occurs at over 75% extractions. Thus, countries exposed to extremely high-water stress about less than 80% are Libya, Israel, Egypt, Jordan, Saudi Arabia, Turkmenistan and Uzbekistan, while high water stress about 40–80% affects China, India, Afghanistan and South Africa. The United States and Kazakhstan have low–moderate water stress about 10–20 percent, and South America, Canada and Russia respectively, experience low water stress about less than10%.



Source: Adopted from World Resources Institute Aqueduct Country Rankings. [77].

Figure 5: Global water withdrawals by sector, between the years 1960–2014

In a sustainable reality, however, neither freshwater resources nor the population is evenly distributed globally. Inconstant densities of human societies and irregular distribution of water resources, are factors that manage the indicator of water scarcity at numerous levels of risk. An analysis of data collected in 2019 by Aqueduct, a tool developed by World Resources Institute, was conducted by Hofste R.; Reig, P.; [78] and found that water stress is extremely high in 17 countries, high in 27 countries, medium-high in 24 countries, low-medium in 32 countries and low in 63 countries. Nowadays, one-third of major cities are subjected to high or extremely high-water stress (World Resources Institute, Aqueduct Country Rankings 2020) and at least 11% of the European population experiences water deficit [79].



Source: (Adopted from Bixio, d.; thoeye, c.; de koning, j.; et al., 2006) [75]

Figure 5: World countries ranked according to their water stress index green, yellow & red horizontal lines represent the thresholds for low, moderate & high-water stress, respectively

Taking 2025 as a reference year, it was estimated that approximately 3.5 million people worldwide could experience water scarcity while in developing countries 1.2 million people with a risk of increase to 1.8 million will live in water-scarce areas due to the absence of unreliable policies or convenient management strategies for reusing treated wastewater in crop production (Food and Agriculture Organization of the United Nations 2020) [80].

Water consumption registers a significant increase from year to year. A report released in 2017 by the European Environment Agency shows that in Europe, agriculture consumes 36% of total water. Public water demand consumes 32%, service sector 11% and other needs 21% (European Environment Agency. 2017). Based on the evolution of freshwater withdrawals between 1960 and 2014 (World Resources Institute.

[77] Aqueduct Country Rankings, it is concluded that agriculture is the largest global user of freshwater about 70% for crop cultivation and animal husbandry, registering an increase of 100% in the last century; the industry consumes 19%, meaning that industrial water demand increased three-fold in the last century; since the 1960s, the population grew by more than 4 billion and the withdrawals for domestic consumption increased by about 600% as shown on (No. 2).

4. Wastewater reuse in irrigating agriculture of sustainable practice

Huge volumes of wastewater are generated daily in households, industries and agriculture. The volume of wastewater accounts for 50–80% of the domestic household water uses [81] and the global wastewater discharge was estimated at 400 billion m3/year, polluting approximately 5500 billion m3 of water/year, as reported previously [82]. Wastewater usually consists of 99% water and 1% suspended, colloidal and dissolved solids [83].

It is well known that wastewater, depending on its source, is loaded with pollutants such as organic matter, suspended solids, nutrients, mainly nitrogen and phosphorus, heavy metals, emerging contaminants with antibiotics, hormones, personal care products, pesticides, polycyclic aromatic hydrocarbons, phenolic compounds, volatile organic compounds, antibiotic resistant bacteria and genes and pathogenic microorganisms like bacteria, viruses, protozoans and parasitic worms Agro-industrial wastewater has an important content of nutrients.

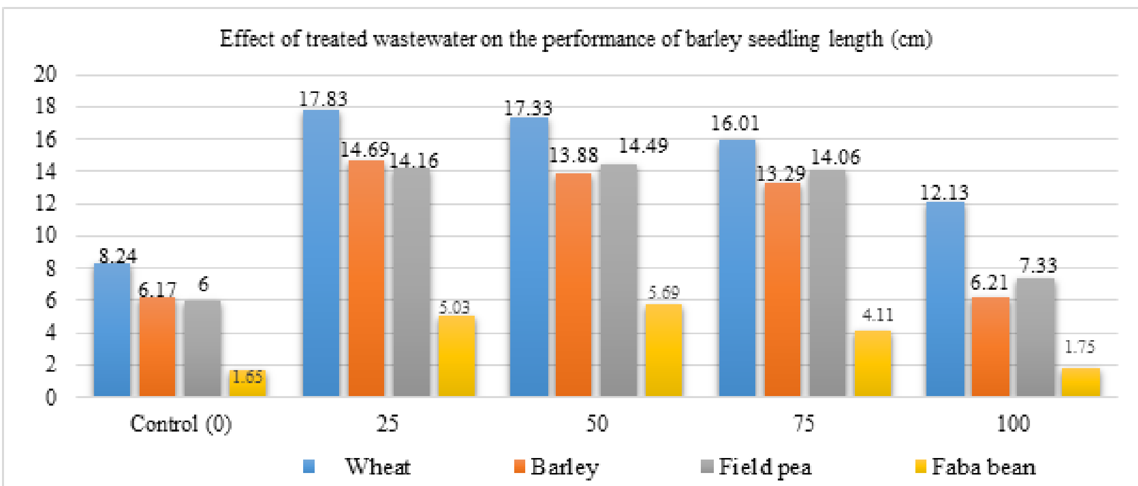
Therefore high potential to be used in agricultural irrigation because it supplies organic carbon, nutrients (NPK) and inorganic micronutrients to the crops [84]. Many studies emphasize the usefulness of wastewater and especially of treated water for crop irrigation, in terms of benefits expressed by increased crop productivity [83, 85]. due to the high content of nutrients in these waters. Jang, T.; M. and Lee, et al., (2013) reported a 15% increase in rice productivity and [86] obtained a 114.9% increase in tomato irrigated with wastewater. A recent study of [87] showed that due to the nutrient content, the reuse of treated municipal wastewater in countries like Brazil, Poland and Saudi Arabia would cover 100% of both phosphorus and potassium requirements for maize crops. Wastewater reuse for irrigation of agricultural crops is a market-driven action based on the requirements of the agricultural sector and can contribute to the promotion of the circular economy by recovering nutrients from the reclaimed water and applying them to crops by different fertigation methods.

Wastewater reuse in irrigating agriculture is often practiced in low-income, arid and semi-arid countries[88] where evapotranspiration outpaces precipitations for most of the year [89]. The availability of treatable wastewater in nearby communities' and large farm owners as well as state organizations working on small and large farm lands increases the selection of crops that farmers or producers can grow. Due to its multiple benefits, this practice is gaining wider acceptance in many parts of the world. Although the younger population, which has access to education and sources of information on the benefits of reusing wastewater as irrigation water, has a positive attitude towards this practice, the older population is still reluctant in accepting to consume food from crops irrigated with wastewater [90].

Some of the advantages offered by the capitalization of wastewater treated, partially treated or diluted in agriculture are the following: availability of large quantities of water throughout the year without being affected by climatic conditions, high nutrient content that can reduce the use of chemical fertilizers, increasing the productivity on less fertile soils, reducing the damage to freshwater ecosystems associated with eutrophication and algal blooms, etc [91]. Although the benefits of wastewater use in agriculture are multiple, there are also various disadvantages of this practice, including various diseases in farmers and consumers of food from wastewater irrigated crops; accumulation of heavy metals, salts, antibiotics, growth hormones and other hazardous substances into the soil; low hydraulic conductivity due to clogging of soil pores with suspended solids from wastewater; decreased quality of agricultural crops, because they will accumulate the pollutants transferred from wastewater to the soil, etc.

Field Experiment & Laboratory Test Results of Wastewater on Crop Growth Performance

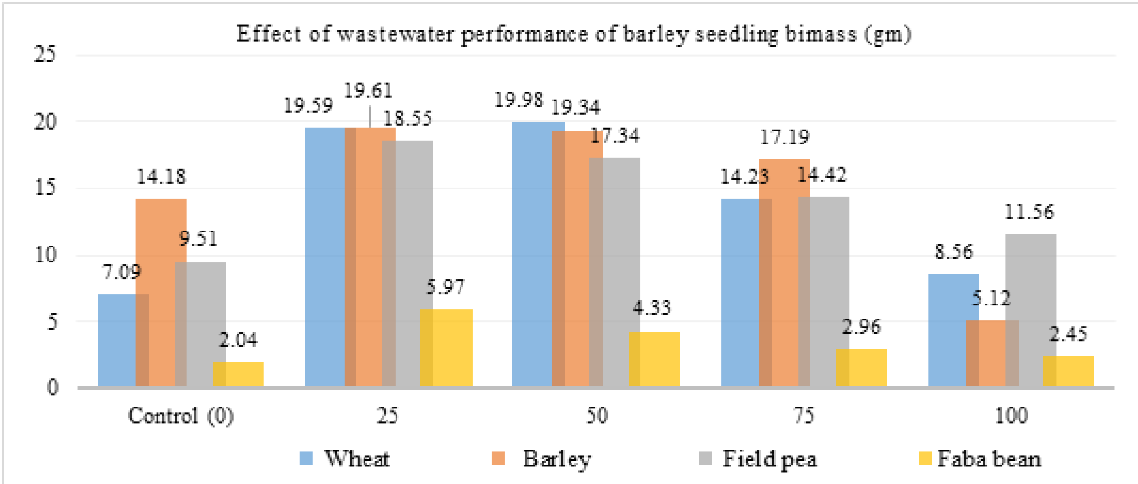
The field experiments including the laboratory analysis activities has been carried out to verify the quality of the wastewater. Pursuant to the field experiments and laboratory test results of the vegetative growth tests on numerous field crops in order to verify the required quality of the wastewater has been found to be nontoxic and safe to use it for irrigating agriculture (Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., 2021). The study results of pot experiments on the performance of wheat, barley, field pea and faba bean watered with the wastewater brought from Asella Malt Factory as shown on (Figures 7-10).



Source: Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., [92].

Figure 7: The effect of treated wastewater on the performance of barley seedling length (cm)

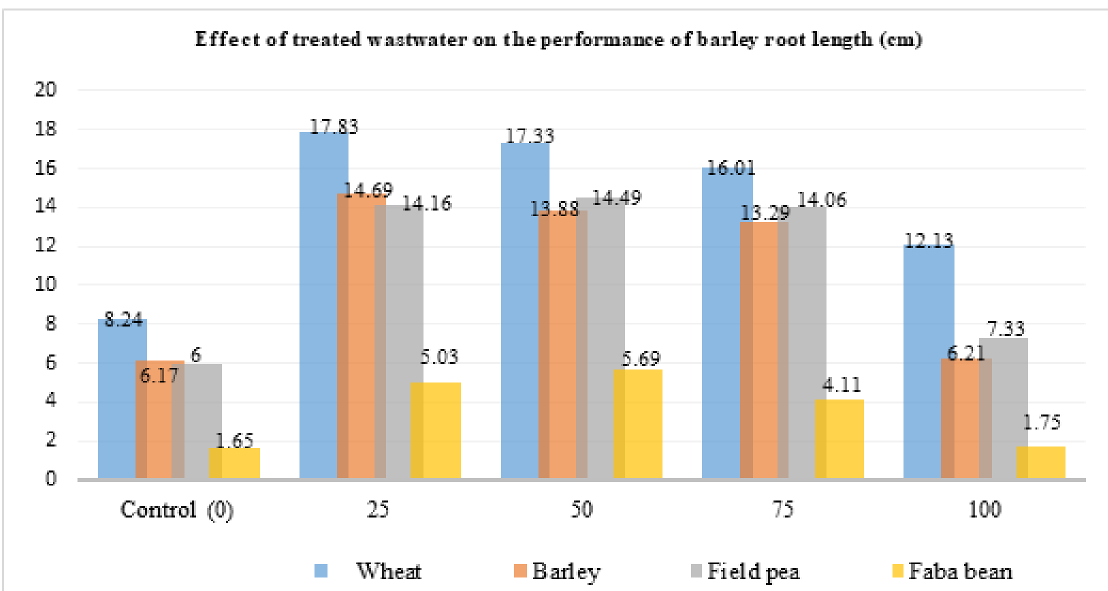
On the other hand, this is the result of environmental control growth chamber of the glass pot experiment to prove the reliable quality of the wastewater and tiled observation has proved that the water soaked malt barley wastewater discharge is applicable with proper percentage of freshwater dilution to use it for irrigating agriculture tasks.



Source: Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., (2022).

Figure 8: The effect of treated wastewater on performance of barley seedling biomass (gm)

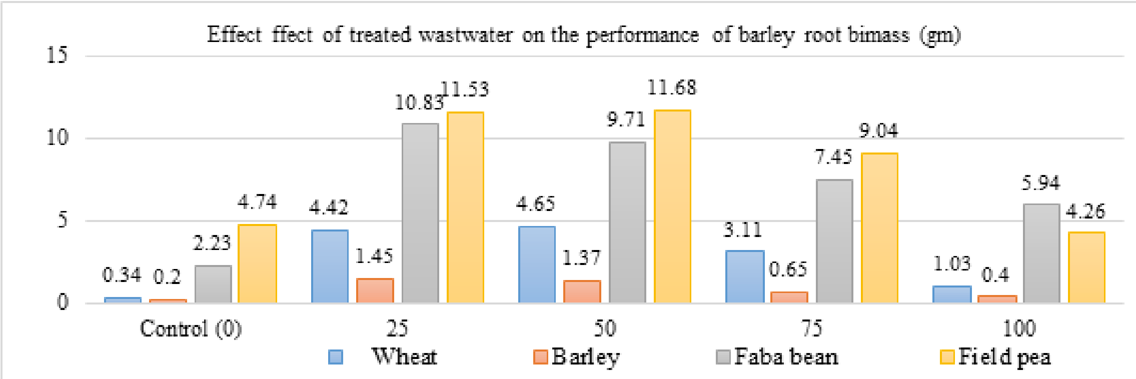
Now that the research center itself and the downstream dwellers have begun using the treated wastewater for irrigation purposes. It is due to the research findings that the KARC and the downstream dwellers have begun producing at least twice a year and increasing their production per unit area per year.



Source: Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., (2022).

Figure 9: The effect of treated wastewater on the performance of barley root length (cm)

On the basis of the wastewater diversion to Kulumsa Agricultural Research Center for irrigation, the eroded gullies being formed alongside of the main asphalt has been rehabilitated. Apart from this, there is a 100 m of an open concrete ditch with four silt trap basin structures, so as to minimize the gradually accumulated sediments of the ponds. Those sediments, which steadily gathered from manhole and open ditch are used as natural compost or predominantly it can be utilized as an organic fertilizer. Thus, from now on, there are no any possibilities of industrial wastewater resources depletion potentials (Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., 2021).



Source: Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., (2022) [92].

Figure 10: The effect of treated wastewater on the performance of barley root biomass.

According to the results of quality tests conducted at the National Soil Testing Center, the AMF's wastewater (barley washed-out discharge) is environmentally friendly for agricultural production activities. Therefore, shortening of the technology generation process and significant contribution towards the supply of preliminary materials for technology development are possible. Reusing of wastewater for irrigating agriculture in accordance with the research findings, instead of discarding the wastewater as unwanted waste, the research center and the downstream dwellers have begun using it for irrigating their farm lands. It is due to the research findings that the KARC and the downstream dwellers have begun producing at least twice a year and increasing their production per unit area of the whole years.

On the basis of the wastewater diversion to the KARC for irrigation functions and the eroded gullies being formed alongside of the main asphalt have also rehabilitated. Apart from this there is a 100 111 of an open concrete ditch with four silt trap basin structures, so as to minimize the gradually accumulated sediments of the ponds. Those sediments, which steadily gathered from manhole and open ditch are used as natural compost or predominantly it can be utilized as an organic fertilizer. Thus, there are no any possibilities of industrial resources depletion.

According to the results of quality tests conducted at the National Soil Testing Center, the industrial wastewater is environmentally pleasant for irrigating agricultural production purposes. Hence, shortening of the technology generating process and it has significant contribution towards the supply of preliminary materials for technology development is possible. In accordance with the above-mentioned research findings for proper utilization of the wastewater, there is a need to mix the freshwater with the barley washed-out wastewater in order to get a suitable dilution at 25%, 50%, and 75% depending on the actual size of the field crops and vegetables all with using of the newly developed the freshwater and wastewater mixing chamber. Agro-industrial wastewater can be considered as both as a resource supply and a means of the problem.

The reusing of wastewater has been rapidly grown because of irrigation water scarcity, increasing of population and industries as well as the urban extension. The main physiognomies used for wastewater characterization are organic matter, measured as biochemical oxygen demand (BOD). Suspended solids, nutrients (N, P), fecal coliforms bacteria, and toxic substances. Industrial wastewaters are usual! Biologically degradable. Some contain high BOD (1000-20.000 bod/mJ). However, the quantity and quality of wastewaters diverge widely from industry to industry. High BOD concentration is not accepted for discharge into watercourses. It is not recommended to discharge wastewater in to river or some other natural watercourses.

Generally, there are two options of disposing industrial wastewaters. The first is to discharge the wastewater into a sewer system - where applicable - while the other method is to industrial waste alone. If the agro-industrial wastes consist of strengths of characteristics that are significantly different from sanitary wastewater, pretreatment should be considered at the industrial site.

Since the wastewater coming out from Asella Malt Factory has been diverted to Kulumsa Agricultural Research Center, it will no more causing health problems and predicament to the upstream dwellers as to the previous times. Reusing barley washed-out water for irrigation was creating soil erosion in the form of gully structure while passing through its previous course (Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., 2021). The gully was at its active stage and increasing in both depth and width.

The Productive Effects of Agro-Industrial Wastewater Discharges

Brief discussions concerning the productive contributions of reusing the agro-industrial wastewater discharges by treating with a proportional percent of freshwater dilution now that initially taking place at the irrigation project of Kulumsa Agricultural Research Center and at the surrounding society have been discussed here underneath.

Reusing of treated wastewater for crop irrigation has a great productive effects and can also contribute to diminish water stresses. The use of domesticated agro-industrial wastewater for irrigation purpose was demonstrated by numerous studies and full-scale installations. On the other hand, reuse of industrial wastewater in irrigating agricultural is scarce and the awareness in this field is limited. This work aims at cherishing the suitability of agro-industrial wastewater to reuse it for irrigation (Anbessie Debebe A., Kassu Tadesse K., & Samuel Lindi M., 2021).

Conclusion

The complete outcomes of this review study shows the tendencies along with clear gaps in our understanding of wastewater use in irrigated agriculture, backing results from case studies commissioned by the Comprehensive Assessment of Water Management in Agriculture and the past studies conducted by the International Water Management Institute and other institutions, and current literature. The study shows that the main drivers of wastewater use in irrigated agriculture are the arrangement of three factors in most cases:

- Increasing irrigation water demand and related return flow of used but seldom treated wastewater into the environment and its water bodies, causing pollution of traditional irrigation water sources.
- Lack of alternative, cheaper, similarly reliable or safer water sources which restricts the handling capability of irrigation water.
- The key underlying factor in most cases is insufficiency which limits the managing capacity of irrigation water with comprehensive wastewater treatment. The study also establishes the following characteristics of wastewater use.

In our case, the wastewater treatment method for irrigation functions comprising:

a wastewater source coming out from the Asella Malt Factory to the reservoir ponds which have covered with a sealed geomemberane sheets; the sludge discharging manholes and the wastewater treating chamber in a pipeline connection with the treated wastewater handling units located at a lower elevation than the wastewater and freshwater storage ponds; and also a diluted water pump capable of transporting the treated wastewater dilutions from the mixing chamber to the irrigation farm lands.

- The wastewater treatment structure, further comprising: a sprinkler irrigation system located around the downstream farm lands of which are connected with the treated wastewater lagoons and in moveable pipeline connecters.
- As a result, some different field crops of seeds which were immersed in the wastewater extract have shown different growth performance due to various dilution percentages of the wastewater concentrations.
- The emerged seedlings of cereal crops such as barley and wheat, pulse crops such as field pea and faba bean seeds that were socked in the different percentage of dilutions of the wastewater and fresh water have performed very well than the non-treated fresh water control plots.
- The fresh water control plots have revealed that the cereal crops such as barley and wheat as well as the pulse crops of field pea and faba-bean seeds which were socked in the fresh water have seen to be distorted and have given an poor growth performance of the seedlings due to the deficiency of some more important nutrients such as biochemical features of extracts showed that it represents PH range from 4.5-6.0, which contains 0.6 % of dry substances, 2.6 % of nitrogen, 1.4 % of Phosphorous, and 2.1 % of Calcium.
- In the agro-industrial wastewater, we can find groups of vitamins such as B-thiamin, pridioxine, nicotinic acid inositol, biotin, ferments of the breathing and oxidizing-restoration complex-catalase, peroxides, polyphenol oxidize, dehydrogenase, ascorbictoxidase, hydrolytic ferments-amylase, phophatase, phytohormons- gibberellins, auxins, cytokenins; nucleic acids- DNA and RNA; amino acid, organic acid carbohydrate, and other junctions.
- It has been observed that a poor growth performance and a distorted structure of the shoots and the roots part of the plants at 0% of a non-diluted fresh water control plots of seedling development due to the deficiency of nutrients which could be obtained from the malt barley washed-out extracts.
- The cereal crops such as barley and wheat as well as the pulse crops of the field pea and faba bean seeds which planted in the treated barley washed-out extract of the Asella Malt Factory have performed very well at 25% and 50% dilutions in favor of their intensive growth rate performance of the seeds.
- The cereal crops such as barley and wheat as well as the pulse crops of the field pea and faba bean seeds which planted in the treated barley washed-out extract of the Asella Malt Factory have performed a somewhat well at 75% dilution, however it has some germination effects on their normal growth rate of the seeds.
- The cereal crops such as barley and wheat as well as the pulse crops of the field pea and faba bean seeds which planted in the treated barley washed-out extract of the Asella Malt Factory have shown unfavorable growth performance at 100% dilution and most of the seeds are not germinated due to the over saturated diffusion of the nutrients.
- Under field management conditions, it has been observed that a poor growth performance and a distorted structure of plants at 0% of a non-diluted wastewater control plots of seedling development due to the deficiency of nutrients which could be obtained from the immersed malt barley washed-out extracts.
- Based on the laboratory test findings, the barley washed-out wastewater extracts coming out from the Asella Malt Factory has been tested under field management conditions on 13 different field crops for their good performance to be used as a wastewater on the large scale farms and experimental plots.
- The vegetable seeds tested with the barley washed-out extract have performed very well at 25% fresh water and 75% barley washed-out extracts of the Asella Malt Factory in favor of their exhaustive growth rate of the plants.
- Depending on their extensive scope of the cereal crops which

have tested in the treated wastewater of the Asella Malt Factory have been performed very well at 25% to 50% fresh water dilutions in favor of their intensive growth rate of the plants. Because of their unique nature and their very dissimilar size of the Oil crop seeds they have not need much more nutrients for their full growth of periods to be irrigated under the field management conditions with the treated barley washed-out wastewater of the Asella Malt Factory have been performed very well at the 75% fresh water and 25% barley washed-out wastewater of the Asella Malt Factory in favor of their exhaustive growth rate of the plants.

To sum up, countries must address the need to develop policies and locally viable practices for safer wastewater use to maintain its benefits for food supply and livelihoods while reducing health and environmental risks. Successful establishment of treated wastewater irrigation project will have an extreme role for the research tasks and for seed multiplication programs of the KARC as well as for other similar centers of the EIAR and of course, an extra agricultural productivity increment will be created for neighbor peasant associations as well as all over of the far and the nearby farmers. Proper inspection and a timely checkup of the canal structures are very essential so as, to keep away from any probable damages and possible failures of the ponds, which might be caused by undefended overflows and unprotected water loggings.

At present, the accessible wastewater can irrigate a minimum of about 40-70 ha, but in the future it should irrigate a maximum of about 150-250 ha. It's the author's deep conviction that the wastewater irrigation endeavor could have mutual benefit for Kulumsa Agricultural Research Center and for neighbor peasant association farmers. Significantly speaking, with a good management, the appropriately treated wastewater irrigation establishment should create a real change of life at once for the surrounding population as promptly as the target No.s and as alike as the proposed objectives of the irrigation projects establishment [93-102].

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