Running Head: THE USE OF WASTE WATER FOR DRINKING

Introduction

This is a research paper on the reuse of waste water for drinking. Waste water is any form of water that contains harmful substances which negatively affect the quality of water. These harmful substances may include liquid wastes discharged after use and sewage. The research paper will focus on and discuss the topic, “Purified Recycled Water for Drinking: The Technical Issues. It will hence look at the different methods/technical issues of using waste water. It will similarly analyze the various risks involved in these methods and considerably discuss the benefits derived from the use of the waste water. The research paper will finally draw a conclusion regarding the entire topic of reusing waste water. The research paper will involve the use of tables, figures and charts in aid of forming a comprehensive discussion and an informed conclusion.

Background

Water is life. However in the modern times, water has been rendered to as the scarcest resource for this survival by animals, plants and other living things in need of it. This scarcity has been as a result of increased population in the world, climatic changes which have led to low rainfall levels, droughts and reduced underground water (Gardner, 2008). Due to this scarcity, increased population, increased urbanization, increased use of quality water, and rising fertilizer prices, the need to reuse waste water has increased relatively (World Health Organization, 2010). To match the demand, waste water must be purified for reuse. As described earlier, wastewater contains harmful impurities which include; liquid wastes, sewage- water, urine, feces and other impurities. Waste water also contains chemicals like; nitrogen, phosphorous, chloride, grease and others (FAO, 2010; Binnie et al., 2002; Holland, 1999).

Constituents of Waste Water

The following table shows the main wastewater pollutant and concentrations (Gardner, 2008).

Component group	Measurement and typical values in Waste water	Description
Organics	5-day Biochemical Oxygen Demand BOD: 200-300mg BOD/L	Partial measure of the biodegradable Organic content
	Chemical Oxygen Demand COD:400-600mg COD/L	Measure of total organic content
Solids	Total Suspended Solids TSS:200-300mg TSS/L	Measure of particulate material(separated by filtration)

	Volatile Suspended Solids VSS:170-260mg VSS/L	Measure of particulate organic material
Nutrients	Ammonium-Nitrogen NH4-N:30-45 mg N/L	Measure of Nitrogen in form of Ammonium (soluble)
	Nitrate-Nitrogen, Nitrite-Nitrogen NO3-N, NO2-N:typically zero in waste water	Measure of Nitrogen in form of Nitrate or Nitrite (soluble)Measure of organically bound nitrogen in complex molecules(e.g. proteins)
	Total Kjeldahl Nitrogen TKN: 40-60 mg N/L	Measure of organically-bound nitrogen in complex molecules (e.g. proteins)
	Total Nitrogen TN: 40-60 mg N/L	Measure of total nitrogen content (TKN+ NO3-N +NO2-N)

	Phosphate-Phosphorus PO4-P 8-12 mg P/L	Measure of phosphorus in the form of phosphate (soluble)
	Total Phosphorus TP: 10-15 mg P/L	Measure of organically-bound phosphorus in complex molecules, plus phosphate
Salts	Total Dissolved Solids TDS: 200-100 mg TDS/L	Measure of soluble components (mainly salts some organics and nutrients). Highly variable and depends on local water quality and groundwater/sea water infiltration into waste water system.

It also contains suspended and dissolved solids at different concentrations depending on the source of the waste water. Wastewater can therefore be derived from human wastes, washing water, septic tank discharge, flood water, industrial waste, drainage water, industrial site drainage, agricultural drainage, toxic waste, organic waste, rainfall collected from roofs, and ground water inflated into sewage. All these makes wastewater unfit for consumption and hence must be purified for it to be recycled. Water purification is the removal of contaminants from wastewater for purposes of improving the quality of wastewater with an intention of reusing it. Water recycling on the other hand is the reuse of treated waste water from one application to another (McKenzie, 2010; Ramstop, 2003; Rona et al, 1995; Vigneswaran, & Visvanathan, 1995).

Methods used on potable reuse of wastewater

Potable reuse is the use of recycled water of standard quality for purposes of drinking. There are many recommended methods of treating wastewater for portable use as detailed here in. Treatment of wastewater involves a sequence of processes: primary, secondary and tertiary. The processes can be chemical, biological or mechanical depending on the contaminants. The first stage is generally the preliminary/primary stage where the process technologies used vary from mechanical screening, sedimentation to floatation. In this stage large particulates like; plastics, logs, tennis balls and rags are removed through floatation. Large/heavy suspended solids are also removed through mechanical screening. Small solids like; Sand, grit and silt are removed at this stage through sedimentation. Insoluble liquids like grease, fat and oils are removed at this stage through floatation. No pathogens are removed at this stage. However, more contaminants could be removed at this level depending on the components of the waste water. The residue then passes on to the secondary treatment stage. The process technologies at this stage involve; biological degradation of soluble organics, physical capture of particulates including pathogens, and further sedimentation. Soluble organics like nitrates are removed aerobically by biological degradation. Smaller particles like soil are removed by further sedimentation. Some pathogens like cholera vobrio bacteria and enteric viruses are removed by enmeshing through sedimentation. Other micro pollutants of water are removed at this stage through sedimentation and biological degradation (United States, 2002; Bitton, 2005; Surampalli, 2004).

Some soluble contaminants would not be removed at this stage and hence a more complex process is required. The residue then passes on to the tertiary treatment stage which involves; biological nutrient removal, chemically-assisted nutrient removal, filtration and disinfection. Dissolved nutrients like nitrogen and phosphorus are removed biologically through nitrification-denitrification and through chemically-assisted technological process. The remaining particulates up to this level are removed by filtration and destruction. The complex pathogens at this stage like nematodes and enterovirus are removed by disinfection. Disinfection relates to use of chemical like in chlorination, chlorine is used as an oxidizing agent to inactivate bacteria and viruses. It also oxidizes any remaining residual organics and ammonium. Ozonation is also part of disinfection where ozone is used as an oxidizing agent to destroy microorganisms like bacteria. Ultraviolet light which is also a disinfectant prevents microorganisms from reproducing by destroying their nucleic acids. Lastly is the membrane technology which provides a fine barrier to the passage of pathogenic microorganisms hence, removing bacteria (Gardner, 2008; Cheremisinoff, 2002; Delovitch and Ringskog, 1997).

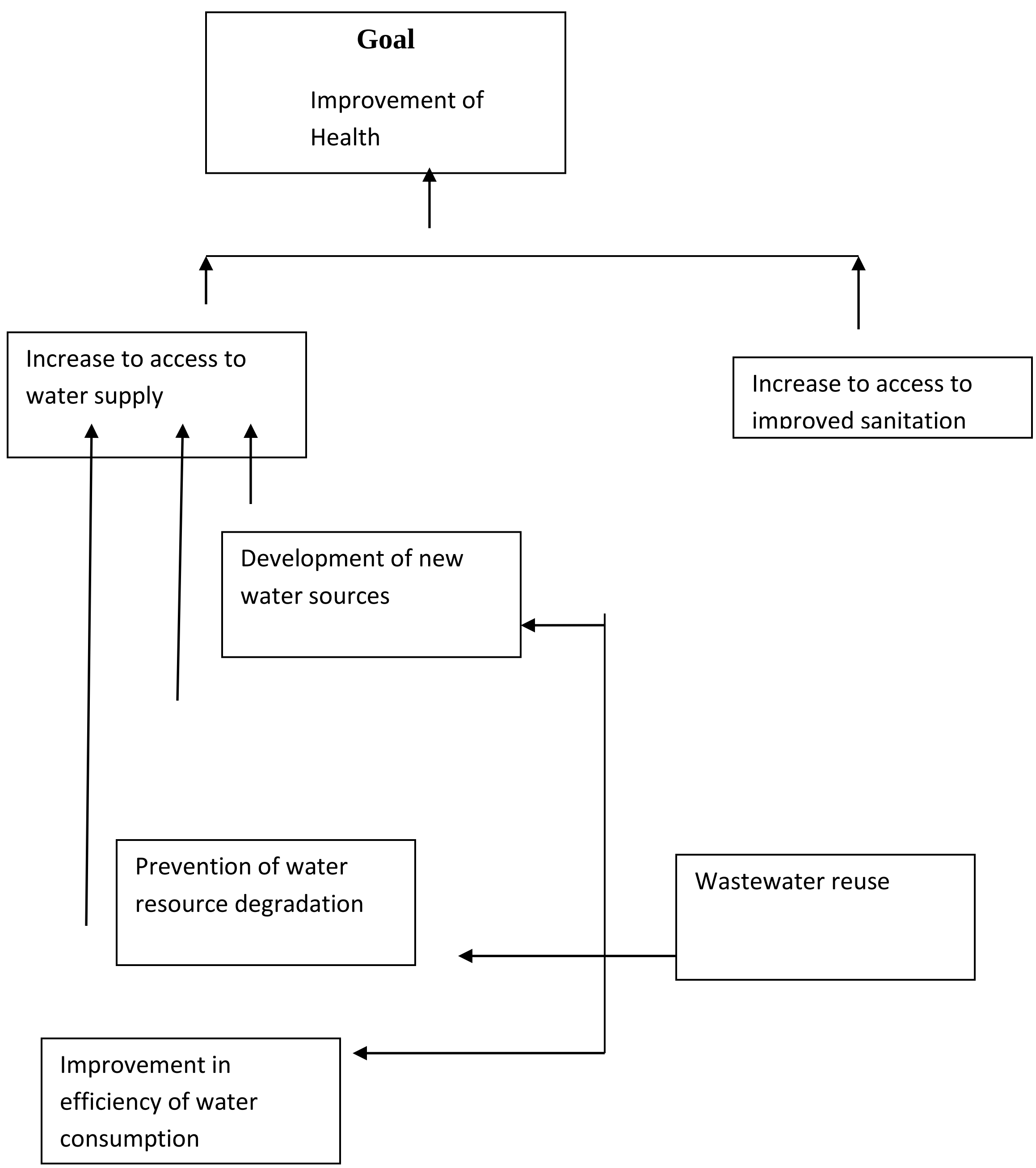
Oxidative processes are used to degrade any organic constituents that are biologically recalcitrant and activated by carbon. The final process of water treatment is stabilization. Stabilization prevents the water from damage by corrosion and dissolution to the fixtures and fittings used in the distribution of the treated water for portable reuse. To this extent, the water is pure for recycling and can be use for various purposes like; agriculture (Research themes, 2003), industries, washing, bathing, and potable reuse (Henze, 2002; Hendricks, 2006; Gottschalk, Libra, and Sauper, 2000).

Risks involved in use of waste water

However, a number of risks are eminent on using this water for potable reuse. Public health is a point of consideration when it comes to recycling water for drinking purposes. There is the risk of the presence of chemicals in treated water whose impacts could be dire to the human health. The presence of low levels of environmental concentrations of endocrine disrupting compounds which are harmful to human health. The creation of new chemicals everyday and their subsequent release into the water cycle is risk in that water treatment plants already in place, may not have the capability to remove these chemicals. The ambiguity of chemicals is also another risk to the potable reuse of recycled water. There are many unknown chemicals or mixtures being released and hence not easy to remove them. There is also the emergence of new contaminants which are easily treatable (Russel, 2006; Loosdrecht, and Clement, Jonathan, 2005; Smith, and Smith, 2005). The time that we expose ourselves to the treated water is equally risky because more chemicals were used to treat this wastewater and hence not 100% pure. It is worth realizing that no margin of error/risk is allowed when the recycled water is for potable reuse. There is a cost effect related to the establishment of a water treatment plant and not everybody can afford. Hence there is a risk of somebody not treating the water comprehensively due to lack of enough funds (Vesilind, Morgan and Heine, 2009; Omelchenko, Pivovarov Pivovarov and Swindal, 2005; Reiter, 2004).

Benefits of recycled water

Upon the assessment and management of the risk involved, pure recycled water is very beneficial. The potable reuse can be categorized under direct and indirect potable reuse of pure recycled water. The indirect potable reuse water is recycled water transported to a reservoir for extraction. The effectively treated water is therefore used for direct injection projects to maintain ground water trust as used in Occoquan Reservoir in the Fairfax County, Virginia (U.S Environmental Protection Agency, 2009). This ground water has largely been used to meet water supply needs making up to one-third of the water supply. The underground water is equally less expensive compared to paying for pipe water from the council. The direct potable reuse ensures the available of water in the taps and tanks hence serving the demand of this scarce resource. On the other hand, the treatment of this waste waster helps in controlling water pollution by extension. Water recycling also helps in finding ways of decreasing the diversion of water from significant ecosystems. It also decreases wastewater discharges hence reducing pollution. It can similarly be used to create wetlands (Jordening, Hans and Winter, 2005). The figure below analyzes the role of waste water reuse:



However, in most countries, recycled water is not directly mixed with potable water because: the ware treatment plants providing recycled water for non potable purposes do not treat the water to the standards of drinking, some pathogens and other chemicals are able to pass through the treatment process and hence harmful for drinking (Fewtrell, Bartram, and World Health Organization, 2001; Rump, 1999; Alley, 1993).

Conclusion

In the US, Florida and California cities are quoted as the leading recycled water users. As observed, potable reuse requires absolute treatment for purposes of public health. Certain pathogens and chemicals have the capability of passing through the treatment posing a great risk to potable reuse. In this case, adequate risk management should be carried out to cater for the risks to improve the efficiency of recycled water. New technologies should be adapted to cope with the evolving chemicals and pathogens. The process of waste water treatment is costly but the returns are significant. Huge benefits are derived from the reuse of recycled water. It ensures constant water supply all over the world and helps in reducing water pollution. Many countries have adapted this method of water supply to supplement the scarce water sources. From the purified recycled waste water, only a small fraction is subjected to potable reuse. There are other major uses of recycled water including agriculture and industrial uses. As the population increases and water scarcity becomes rampant, we can be optimistic that through recycling and reuse we will meet the world’s water needs in a more convenient way. The government should at the same time control the treatment of waste water and regulate the distribution of the treated water since too much exposure is equally risky. I thereby conclude that waste water can be purified for potable reuse.

References

Alley, W. (1993). *Regional Ground-Water Quality*. New York, NY: John Wiley and Sons.

American Society of Civil Engineers and Water Environmental Federation. (1995). *Odor control in wastewater treatment plants.* New York, NY: ASCE Publications.

Binnie, Chris, Kimber, Martin, & Smethurst, George. (2002). *Basic water treatment* (3rd ed.). London: Thomas Telford Ltd.

Bitton, G. (2005). *Wastewater microbiology*. John Wiley and Sons.

Cheremisinoff, N. (2002). *Handbook of water and wastewater treatment technologies*. London: Butterworth-Heinemann.

Delovitch E and Ringskog, K. (1997). *Wastewater treatment in Latin America: old and new options*. New York, NY: World Bank Publications.

FAO. (2010). *Wastewater treatment and use in agriculture*. Fewtrell, L Bartram, J and World Health Organization. (2001). Water quality: guidelines, standards, and health : assessment of risk and risk management for water-related infectious disease. New York, NY: IWA Publishing.

Gardner, T. (2008). *Purified Recycled Water for Drinking: The Technical Issues*.

GESAP. (2010). *water and wastewater reuse*. Gottschalk, C Libra, J and Sauper, A. (2000). *Ozonation of water and waste water: a practical guide to understanding ozone and its application*. New York, NY: Wiley-VCH.

Hendricks, D. (2006). *Water treatment unit processes: physical and chemical*. New York, NY: Taylor & Francis.

Henze, M. (2002). *Wastewater treatment: biological and chemical processes*. New York, NY: Springer.

Holland, F. A., Siqueiros, J., Santoyo, S., Heard C. L., & Santoyo, E. R. (1999). *Water purification using heat pumps.* New York: Routledge.

Jordening, Hans and Winter, J. (2005). *Environmental biotechnology: concepts and applications*New York, NY: Wiley-VCH.

Loosdrecht, M and Clement, Jonathan. (2005). *2nd IWA leading-edge conference on water and wastewater treatment technologies.* London: IWA Publishing.

McKenzie, C. (2010). *what is wastewater reuse?* National Research Council. (1994). *Ground water recharge using waters of impaired quality*. New York, NY: National Academies.

National Research Council. (1998). *Issues in potable reuse: the viability of augmenting drinking water supplies with reclaimed water*. New York, NY: National Academies Press.

National Research Council. (2002). *Privatization of water services in the United States: an assessment of issues and experience*.New Yolrk, NY: National Academies Press.

National Research Council. (2006). *Drinking water distribution systems: assessing and reducing risks*. National Academies Press.

Omelchenko, A Pivovarov Pivovarov, A and Swindal, J. (2005). *Modern tools and methods of water treatment for improving living standards.* New York, NY: Springer.

Ramstorp, Matts. (2003). *Contamination control in practice: Filtration and sterilization.* Weinheim, Sweden: Wiley-VCH.

Reiter, L. (2004). *From source water to drinking water: workshop summary*. New York, NY: National Academies Press.

Research Themes. (2003). *Reuse of Wastewater for Agriculture*. Rona, Zolton P. and Martin, Jeanne Marie. (1995). *Return to the Joy of Health.* Vancouver: Alive Books.

Rump, H. (1999). Laboratory manual for the examination of water, waste water and soil. New York, NY: Wiley-VCH.

Russel, D. (2006). *Practical wastewater treatment*. New York, NY: John Wiley and Sons.

Smith, P and Smith, P. (2005). *Dictionary of water and waste management*. New York, NY: Butterworth-Heinemann.

Surampalli, R. (2004). *Advances in water and wastewater treatment*. New York, NY: ASCE Publications.

U.S. Environmental Protection Agency. (2009). *Water recycling and reuse*. United States. (2002). *Arsenic treatment technologies for soil, waste, and water*. New York, NY: DIANE Publishing.

United States. (2002). *The clean water and drinking water infrastructure gap analysis*. New York, NY: DIANE Publishing.

United States. (2003). *Budget options*. Washington, DC: Government Printing Office.

Vesilind, A Morgan, S and Heine, L. (2009). *Introduction to Environmental Engineering*. New York, NY: Cengage Learning.

Vigneswaran, S. & Visvanathan, C. (1995). *Water treatment processes: Simple options.* Boca Raton, Florida: CRC Press.

Water Environment Federation. (2003). *Wastewater treatment plant design: student workbook.* New York, NY: IWA Publishing.

World Health Organization. (1973). WHO technical report series. New York, NY: World Health Organization.

World Health Organization. (2006). *Guidelines for the Safe Use of Wastewater, Excreta And Greywater: Policy And Regulatory Aspects*. New York, NY: World Health Organization.

World Health organization. (2010). *Safe use of wastewater, excreta and grey water*World Water Assessment Programme. (2003). *Water for people, water for life: a joint report by the twenty-three UN agencies concerned with freshwater*. New York, NY: Berghahn Books.