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Review Article

Waste Water Application: An Alternative Way to Reduce Water Scarcity Problem in Vegetables: A Review

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ABSTRACT

Wastewater, being considered a genuine treasure chest of raw materials and all the other commodities that go down the drain. It may be used to irrigate and resupply the surface and groundwater to the crops and vegetables. To help preserve our water supply, water recycling is an economic and environmentally viable option. Emerging pollutants, recycled water for irrigation of vegetable crops as organic material, suspended particles, nutrients (mainly phosphorus and nitrogen), is a market-driven intervention focused on the demands of the farming sector and therefore can help to the advancement of the sustainable development by recovering nutrients from recycled water and applying them to vegetables by various fertigation processes. Wastewater treatment by settling or filtration is required in order to avoid the obstruction of soil pores and irrigation system emitters. Permanent control of the effluent content of the waste water to be reused is the best indicator for the use of waste water for vegetable production. This review discussed the value of vegetables in the world, the issue of water shortage, the recycling of waste water, the recovery of nutrients and their concentration in waste water, and the positive effects of waste on vegetables from numerous currently available sources.

Keywords: *Wastewater; Water Scarcity; Vegetables; Nutrients.*

INTRODUCTION

Waste water disposal is really being established in arid as well as in semi-arid areas, the use of waste water in agriculture may be a significant factor.

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Properly planned urban waste water usage alleviates issues with surface water contamination and also not only conserves important water supplies, but also uses the nutrients found in sewage to cultivate crops. The existence of this excess water nearby population centres would increase the selection of crops that can be grown by farmers. The specifications for inorganic fertilizer may decrease or remove the phosphorus and nitrogen content of sewage. It is advantageous to consider effluent reuse but with its proper disposal and application measures (Pescod, 1992).

Preserving good health majorly depends on healthy and diverse diet. One way is to increase the supply, accessibility, and utilization of nutrient-dense vegetables (Keatinge et al., 2011). A variety of nutrients, particularly vit C, vit K, folate, thiamin, carotenes, many mineral, trace minerals, and dietary fibre, are useful sources for vegetables as a group (Tyler et al., 1989). Vegetables are important to human health in general, supplying minerals and vitamins, dietary fibers as well as phytochemicals, and decreasing the threats of harmful infections and further health damaging conditions (Dias, 2011). In preserving the body's alkaline reserve, vegetables are valuable. They are valued primarily for their high levels of carbohydrates, vitamins and minerals. There are numerous types of vegetables exists. That can be stems, branches, fruits, roots or seeds that are edible. Every community responds in its own way to their diet (Robinson, 1990).

Since according to Bhatti et al. (2009), water supply amount does not align with the time trend of crop requirements. The demand of water supply is increasing day by day, both regionally and seasonally. In several ways, the lack of water affects crop development. The impact is determined in relation to the phase of growth by magnitude, length, and time of stress. Management is also complicated by the abundant variety of vegetables. Inside a particular plant, water stress can cause restricted growth, stem height, leaf area, chlorophyll fluorescence, and root growth during the vegetation period. Therefore, a main objective in crop breeding is the production of plant species with enhanced overall survival and growth throughout water stress (Waśkiewicz et al., 2016).

Anestimated measurement of nutrients in Indian effluent acquired from 322 Category I towns and cities (CPCB, 1989) revealed that approximately 400 tons of nitrogen, 136 tons of Phosphate, and 480 tons of K_2O are the total amount of plant nutrients produced per day from sewage. This estimate is based on an average value of 50, 17 and 60 mg of nitrogen, P_2O_5 and K_2O per liter of sewage respectively (Dash & Mishra, 1996). Similarly, Hodgkiss & Chan (1983) revealed that waste water has a handsome amount of nitrogen and could be used for growing vegetables and other crops. Waste water contains phosphorous and many other nutrients as well (Stumm & Morgan, 1962). This review discussed the value of vegetables in the world, the issue of water shortage, the recycling of waste water, the recovery of nutrients and their concentration in waste water, and the positive effects of waste on vegetables from numerous currently available sources.

Importance of Vegetables in the World

In nearly 200 countries, vegetables are cultivated. Globally, 392 types of vegetable crops are grown and this data was acquired by a world vegetable survey. Mostly the vegetables, with just a small share frozen, are sold fresh. In Asia, nearly 3/4 of the world's vegetable production occurs, mainly in China, which grows more than half of the entire world's vegetables. Because of the potential revenue value of vegetables, a great portion of the world's land have been allocated to vegetables production. Large scale commercial cultivation is a high input and workers-intensive operation that involves a larger workforce, from growing to manufacturing, including the recruitment of non-family partners and much more dependency on humans during the stages of production, processing and marketing (Dias, 2011). Approximately 0.22 million hectares of vegetable (excluding potatoes) have been cultivated in Pakistan, with a production capacity of 2.88 million tonnes during 2002-2003 (Khalil & Rehman, 1977). A global vegetable survey found that 392 vegetable crops, spanning 70 families and 225 genera, are cultivated worldwide (Kays & Dias, 1995). The utmost common group of vegetables used (53 percent of the total) was vegetable crops from which leaves or young leafy shoots are eaten, followed by vegetable fruits (15 percent). In 2008, the global demand for vegetable seeds was valued at USD 3.5 billion with the subsequent vegetable shares: solanaceous-(30%), brassicas (13%), cucurbit (21%), roots as well as bulbs (16%), massive seeds (13%), leafy and other (7%) (Monsanto, 2009). There has been a yearly growing rate of 5.8 percent in global commercial vegetable seed sales over the last eight years. There are now over 6.8 billion people living on this planet, and it has been estimated that over the next 40 years, global population growth will reach upto 70 million annually. The global population roughly about 90% who resides in Africa, Latin American countries and Asia, is projected to hit around 9.5 billion by 2050 (FAO, 2010). In future years, the global demand for vegetable seeds is projected to expand with the rise in global population as well as its consumption and the emergence of a significant level of development and value added via bio-technology.

Water Scarcity Problem

Together with declining water supplies, the steady rise in water demand has increased the need to explore both classical and advanced water resource management approaches (Ameen et al., 2020). The food policy must not lose sight of the rising shortage of water. Water is a key element of agricultural production. Water shortage has a bad effect on worldwide food safe keeping. The violence of the water shortages has led the United Nations (UN-WATER, 2007) to conclude that water shortage is the most momentous limit to the growth in food production over the next few decades. Australia, for instance, is one of the main countries producing food abundantly, but recent droughts have drastically reduced their food as well as agronomic production (Goesch et al., (2007), Hanjra Qureshi, 2010). Kamal (2009) reports that Pakistan has 165 million people, of whom at least 41 million are beneath the poverty threshold, 98 million depend on agriculture sector, 50 million does not have the accessibility toward safe drinking water, and that of 74 million have problems with sanitations. The management of water in Agriculture have made it clear that one out of three individuals is actually facing water shortages. In physical scarcity areas, there are approximately 1.2 billion residents, or almost one-fifth of the global population, whereas 500 million people are entering that state. Additional 1.6 billion, or nearly a quarter of the globe's population, face the financial shortage of water where nation lacks the vital infrastructure to get water out of the aquifers and rivers (UN'WATER, 2007).

Theworld is predicted to suffer from severe water scarcity during next five years (Ameen et al., 2020). Drought is the most important sector limiting agricultural crop production (Toor et al., 2020; & Adnan, 2020). The world must therefore concentrate on theeffective use of all water supplies (surface wastewater, underground water and rainfall) as well as on water supply plans that optimize social and economic benefits to the limited water resources while in the meantime, increasing the efficiency of all the sectors of water, in order to alleviate water problems. Special emphasis needs to be put on issues related to equality in water accessibility and social implications of water supply plans during this endeavor (UN'WATER, 2006).

Wastewater Recycling

In agriculture, mostly wastewater is inappropriately used, presenting probable risks to the environment and public health for decades. Wastewater reuse deserve the attention in the sense of scientific progress, because the practice helps to minimize the burden of water usage and helps in declining the water pollution (Jaramillo & Restrepo, 2017; & Zada et al., 2021). Amongst the prehistoric Greeks, who used civic latrines which release these unprocessed water to a storage compartment through a drain structure, and this was noted as the first evidence of sewage water reuse. In addition, the Greek and Roman societies used local waste water at the borders of the main cities (Rome & Athens) (Tzanakakis et al., 2007). Waste water has been diverted to agronomic grounds that should be used as vegetable and crop fertilizer (Cooper, 2001). Approximately 400 m^3/s of raw waste water is released in Latin America and later used to irrigate various crops (Silva et al., 2008).

Specifically, in the context of nutrients, waste water can be a probable source of macro- (N, P, K) and micro-nutrients (B, Ca, Mg, Mn, Fe, or Zn (Barreto et al., 2013; & Liu & Laynes, 2013) wastewater has many effects on physical as well as physiological properties of soil and plants (Salam et al., 2020). Wastewater recycling has actually been reported to improve crop production (Moscoso, 2010; Jemenez, 1995; & Oliveira & Sperling, 2008) and to lead to the condensed use of agricultural fertilizers (Adrover et al., 2012; & Umaña, 2011). Consequently, eutrophication circumstances in water bodies would be decreased, as would the costs of the farmers' use of agrochemicals (Jaramillo, 2014; & Ilahi et al., 2021).

However, there is a need to be concerned about the quality of recycled water and their impacts. Recently, the workers all around the world are fascinated by the standard system of biological waste treatment, and has aided in rising comparatively well-organized, low-price waste treatment systems. Photosynthetic organisms, which have elevated growth frequency, have the probability to competently use the nutrients and have the capability to yield important biomass which might be cultivated in wastewaters, performs a double role in washing out of contaminated water and helping as a foundation of food or compost (Singh & Dhar, 2006; & Wahid et al., 2020).

Nutrients Recovery and Concentration in Wastewater

Septic systems, nutrient recovery (NR), waste water treatment plants (WWTPs), and waste sludge treatments are considered as the best experienced method amongst the waste source recoveries, for example, animal nourishing, agronomic farming, industrialized pre-treatment services has established important consideration over the previous decades because of the applied observations and accessible organization at WWTPs (Shaddel et al., 2019). Wastewater carries nutrients which are necessary for human food consumptions. Advanced farming system depends upon the immense usage of inorganic fertilizers (NPK fertilizers) (Kalsoom et al., 2020; Rehman et al., 2020a; & Rehman et al., 2020b). The excavating of phosphate rocks and Haber–Bosch procedure have been the most frequently used methods for the production of nitrogen and the phosphoric fertilizers. In Europe, the food manufacturing agencies reports 90 percent of the mineral P utilization, in which there is 79% fertilizers and 11% livestock farming. Several studies stated that the unproductive practice of P-fertilizers in food manufactures leads it towards depletion (Van-Dijk et al., 2016; & Roy, 2017). By 2050, the world's population will rise by 1.3 times (Nations, 2017) with 3 times additional P requirements to yield adequate food for such an increasing inhabitant (Tilman et al., 2002). Therefore, the technique of recovering phosphorus from wastewater is one of the most operative approach to pay off for the growing demands as well as to reduce the exhaustion percentage of phosphatic rocks (Holmgren et al., 2014).

Because of the subordinate functional necessity and economic motivation, N-recovery has acknowledged fewer consideration than P-recovery. The elimination of just nitrogen is cost-effective at the present time period, once ammonia has an instant usage on site (Oleszkiewicz et al., 2015). Though, in the coming years, recovery of nitrogen will tackle up, particularly in situation of manure, where the nutrients masses are far advanced allied with sewage-sludge.

Usually, after treatment, few nutrients in wastewater mud are recently being reprocessed and returned to agricultural soils through direct application to the land, for example; through liming, composting, and anaerobic digestion. On the other hand, these methods have disadvantages as well, such as fulfilling the deficiency of complete guaranteed regarding the reliability, satisfaction and accessibility of nutrients and human health hazards as well occurring through the existence of pathogens, organic pollutants, and heavy metals in soil useful mud (Shaddel et al., 2019). Concentrating on the nutrients biomass is the greatest experienced way of apprehending them from wastewater (biotic conduct or algae), or physicochemical separation. In a distinctive municipal waste water treatment plant (WWTP), the liquid that has been excluded from dirt treatment (side stream) has seven to twelve times complex nitrogen and phosphorous absorption related to the ordinary stream and thus, is the primary aim for NR owing to reduced capacity and improved recovery rates. But the other studies have also been specified the various N and P concentration (Marazzi et al., 2019; & Marazzi et al., 2017).

Furthermore, the nutrients naturally found in waste water make it possible to realize savings on fertilizer expenses (Drechsel et al., 2010; Winpenny et al., 2013; Corcoral et al., 2010; & Moscoso, 2010) hence inhibit the unplanned arrival of macro-nutrients (particularly nitrogen and phosphorous) and micro-elements to aquatic reservoirs via secure and environmentally advantageous nutrient cycle.

Positive Effects of Wastes on Vegetables

Globally, human waste is a cherished resource of nutrients for vegetables and organic/living materials aids in the quality of soil, thus make a favorable environment for microbes and improve soil fertility (O'Connor et al., 2005; & Ilahi et al., 2020). Wastes may be accumulated as unprocessed raw sewage (e.g. wastes held by a community gutter system) or septate (e.g. wastes held by a suburban septic system), unprocessed sewage sludge (e.g. those solid materials rescued from wastewater management), or processed sewage sludge (bio-solids) (WHO, 2006a; & WHO, 2006b). In Northern America, humanoid wastes which are used in cultivation is classically in the form of bio-solids, substance which has a minor amount of pathogens than that originate from unprocessed substances (Pepper et al., 2010).

For irrigation purpose the use of wastewater can have a significant impact on reducing water pollution, increasing water use and restoring the nutrient content of the soil. One of the experiments was conducted by Jahan et al. (2020) at the Agricultural University Bangladesh, to inspect the effects of irrigation with wastewater on physico-chemical soils (conduction (EC), pH, organic matter (OM), phosphorus, nitrogen, potassium (K), sodium (Na) and sulfur (S)) as well as the crop and the production that compromise the features of tomato plants. Through their experiment, irrigation water such as; normal water, home wastewater, civic wastewater and industrialized wastewater were used for triple treatment. Soil and fruits were collected for inspection in the last reap. Thus they concluded from their results, that maximum of the chemical elements; such as OM content, N, K, S, Na and EC was greater in contaminated water treated soil in comparison with that irrigated with conventional water. Amongst the treatments, plant tallness, LAI and production were also greater in plants treated with wastewater in comparison with the conventional water system.

Additional benefits were also raised in the form of higher yields due to irrigation with municipal wastewater in comparison with local and industrialized wastewater irrigation systems and this was proved from the cost benefit analysis in the study. They concluded that municipal wastewater irrigation has a great impact on nutrient content of the soil and also proved beneficial for tomato plants. Another experiment was carried out by Kumar et al. (2016), to investigate the agronomic reaction of okra hybrid cultivar named (*Hibiscus esculentus* L. var. JK 7315) grownup in subordinate processed urban wastewater irrigated field. They concluded that the concentrations of the urban wastewater presented a substantial ($p < 0.05$/$p < 0.01$)

impact on the parameters of soil when fertigated with wastewater compared to underground water in both times of the year. About 60 percent concentration of the urban wastewater in both the seasons was documented as the maximum agronomic performance of the *H. esculentus*.

CONCLUSION

To recapitulate the advantages of the wastewater in vegetable production in safe environments regarding the environment and health, it is imperious that the farming community must be knowledgeable about the dangers and the dealings of decent practices in this regard. Environmental and health risks, as well as the consumption of fresh water is greatly reduced as a result of using only processed wastewater for irrigation purposes whenever is possible. Farming community must need to monitor soil properties of wastewater irrigated lands and the scheduling of irrigation system for the reason that in case the vegetables are irrigated earlier than the growing of the edible part, it may diminish the risk of pathogens contamination. Lastly, irrigating the vegetables through wastewater must be stopped before their harvest.

REFERENCES

Adnan, M. (2020). Application of Selenium a Useful Way to Mitigate Drought Stress; A Review. *Op. Acc. J. Bio. Sci. Res*. *3*(1), 1-4. DOI: 10.46718/JBGSR.2020.01.000064.

Adrover, M., Farrús, E., Moyà, G., & Vadell, J. (2012). Chemical properties and biological activity in soils of mallorca following twenty years of treated wastewater irrigation. *Environ. Manag. 95*, S188–S192.

Ameen, A., Jabeen, F., Qadir, S. A., Ahmed, M., Anum, F., Mubeen, H., Saeed, F., Raza, S., Ilahi, H., Azeem, M., Uddin, M. N., & Room, S. A. (2020). Water Sensitive Urban Design for Rain Water Harvesting and Groundwater Recharge. *Adv, Biores. 11*(5), 13-20.

Barreto, A., Do'Nascimento, J., Medeiros, E., Nóbrega, J., & Bezerra, J. (2013). Changes in chemical attributes of a fluvent cultivated with castor bean and irrigated with wastewater. *Rev. Bras. Eng. Agr. Amb. 17*, 480–486.

Bhatti, A. M., Suttinon, P., & Nasu, S. (2009) 'Agriculture Water demand management in Pakistan: A Review and Perspective' paper presented at the Society for Social Management Systems.

Cooper, P. (2001). Historical aspect of wastewater treatment. In Decentralised Sanitation Reuse: Concepts, System and Implementation; IWA Publishing: London, UK, pp. 11–38.

Corcoran, E., Nellemann, C., Baker, E., Bos, R., Osborn, D., & Savelli, H. (2010). Sick Water? The Central Role of Wastewater Management in Sustainable Development: A Rapid Response Assessment; Earthprint: Arendal, Norway.

CPCB. (1989). Water Quality Statistics of India (1988-89); MINARS/3/1990-91 (Delhi: Central Pollution Control Board).

Dash, A. K., & Mishra, P. C. (1996). *Cytobios*. *88*, 11-16.

Dias, J. S. (2011). World Importance, Marketing and Trading of Vegetables. *Acta Hortic. 921*, 153-169. https://doi.org/10.17660/ActaHortic.2011.921.18.

Drechsel, P., Scott, A., Sally, R., Redwood, M., & Bachir, A. (2010). Wastewater Irrigation and Health: Assessing and Mitigating Risk in Low-Income Countries; *International Water Management Institute*, Ed.; Earthscan: London, UK.

FAO, (2010). FAOSTAT data. http://www.fao.org.

Hanjra, M. A., & Qureshi, M. E. (2010). 'Global water crisis and future food security in an era of climate change'. *Food Policy, 35*, pp. 365–377.

Hodgkiss, I. J., & Chan'Mar, B. S. S. (1983). *Environ. Res. 10*, 1-4411.

Holmgren, K. E., Li, H., Verstraete, W., & Cornel, P. (2014). State of the Art Compendium Report on Resource Recovery from Water; International Water Association (IWA): London, UK.

Ilahi, H., Hidayat, K., Adnan, M., Rehman, F. U., Tahir, R., Saeed, M. S., Shah, S. W. A., & Toor, M. D. (2021). Accentuating the Impact of Inorganic and Organic Fertilizers on Agricultural Crop Production: A Review. *Ind. J. Pure App. Biosci. 9*(1), 36-45. http://dx.doi.org/10.18782/2582-2845.8546

Ilahi, H., Wahid, F., Ullah, R., Adnan, M., Ahmad, J., Azeem, M., Amin, I., & Amin, H. (2020). Evaluation of Bacterial and Fertility Status of Rawalpindi Cultivated Soil with Special Emphasis on Fluoride Content. *Int. J. Agric. Environ. Res. 6*(3), 177-184. Retrieved from https://www.ijaaer.com/ojs/index.php/ijaaer/article/view/322

Jahan, K. M., Khatun, R., & Islam, M. Z. (2020). Effects of wastewater irrigation on soil physico-chemical properties, growth and yield of tomato. *Progressive Agriculture*, *30*(4), 352-359.

Jaramillo, M. F. (2014). Potencial de Reuso de Aguas Residuales Domesticas como Estrategia de Prevención y Control de la Contaminación en el Valle Geográfico del rio Cauca. Master's Thesis, Universidad del Valle, Cali, Colombia.

Jaramillo, M. F., & Restrepo, I. (2017). Wastewater Reuse in Agriculture: A Review about Its Limitations and Benefits. *Sustainability*, *9*, 1734. https://doi.org/10.3390/su9101734

Jimenez, B. (1995). Wastewater reuse to increase soil productivity. *Water Sci. Technol. 32*, 173–180.

Kalsoom, M., Rehman, F. U., Shafique, T., Junaid, S., Khalid, N., Adnan, M., & Ali, H. (2020). Biological Importance of Microbes in Agriculture, Food and Pharmaceutical Industry: A review. *Innovare J. Life Sci. 8*(6), doi: https://doi.org/10.22159/ijls.2020.v8i6.39845.

Kamal, S. (2009). 'Pakistan's Water Challenges: Entitlement, Access, Efficiency, and Equity', in Kugelman, M. and Hathaway, R. M. (ed.) running on empty, Pakistan's Water Crisis: Woodrow Wilson International Center for Scholars, Washington, D. C.

Kays, S. J., & Dias, J. S. (1995). Common names of commercially cultivated vegetables of the world in 15 languages. *Econ. Bot. 49*, 115-152.

Keatinge, J. D. H., Yang, R. Y., & Hughes, J. (2011). The importance of vegetables in ensuring both food and nutritional security in attainment of the Millennium Development Goals. *Food Sec. 3*, 491–501. https://doi.org/10.1007/s12571-011-0150-3

Khalil, I. A., & Rehman, S. (1977). Ber (*Zizyphus juyuba* mill) as a nutritive fruit. *J. Sci. Tech. 1*, 126-128.

Kumar, V., Chopra, A. K., Srivastava, S., Singh, J., & Thakur, R. K. (2017). Irrigating okra with secondary treated municipal wastewater: Observations regarding plant growth and soil characteristics. *Int. J. Phyto remediation*, *19*(5), 490-499. DOI:10.1080/15226514.2016.1244169.

Liu, Y., & Haynes, R. (2011). Origin, nature, and treatment of effluents from dairy and meat processing factories and the effects of their irrigation on the quality of agricultural soils. *Crit. Rev. Environ. Sci. Technol. 41*, 1531–1599.

Ma, L., Ma, W. Q., Velthof, G. L., Wang, F. H., Qin, W., Zhang, F. S., & Oenema, O. (2010). Modeling nutrient flows in the food chain of China. *J. Environ. 39*, 1279.

Marazzi, F., Bellucci, M., Rossi, S., Fornaroli, R., Ficara, E., & Mezzanotte, V. (2019). Outdoor pilot trial integrating a sidestream microalgae process for the treatment of centrate under non optimal climate conditions. *Algal Res. 39*, 101430.

Marazzi, F., Ficara, E., Fornaroli, R., & Mezzanotte, V. (2017). Factors affecting the growth of microalgae on blackwater from biosolid dewatering. *Water Air Soil Pollut. 68*, 228.

Monsanto. (2009). Supplemental toolkit for investors.

Moscoso, J. (2017). Aspectos Técnicos de la Agricultura con Aguas Residuales. Availabe online: http://bvsper.paho.org/bvsacd/scan/019502.pdf

Nations, U. (2017). World Population Prospects, the 2017 Revision-Key Findings and Advance Tables; United Nations: New York, NY, USA. Available online: https://esa.un.org/unpd/wpp/Publications/Files/WPP2017_ KeyFindings.pdf

O'Connor, G. A., Elliott, H. A., Basta, N. T., Bastian, R. K., Pierzynski, G. M., Sims, R. C., & Smith, J. E. (2005). Sustainable land application: an overview. *J. Environ.Qual. 34*, 7–17. doi:10.2134/jeq2005.0007.

Oleszkiewicz, J., Kruk, D. J., Devlin, T., Lashkarizadeh, M., & Yuan, Q. (2015). Options for improved nutrient removal and recovery from municipal wastewater in the Canadian context. *Environ. Technol. 20*, 132.

Pepper, I. L., Brooks, J. P., Sinclair, R. G., Gurian, P. L., & Gerba, C. P. (2010). Pathogens and indicators in United States class B biosolids: national and historic distributions. *J. Environ. Qual. 39*, 2185–2190. doi:10.2134/jeq2010.0037.

Pescod, M. B. (1992). Wastewater treatment and use in agriculture - FAO irrigation and drainage paper 47. Food and Agriculture Organization of the United Nations. http://eprints.icrisat.ac.in/8638/1/RP_07946_wastewater_treatment.........pdf

Rehman, F. U., Kalsoom, M., Adnan, M., Toor, M. D., & Zulfiqar, A. (2020a). Plant Growth Promoting Rhizobacteria and their Mechanisms Involved in Agricultural Crop Production: A Review. *Sun Text. R. Biotech. 1*(2), 1-6.

Rehman, F. U., Kalsoom, M., Nasir, T. A., Adnan, M., Anwar, S., & Zahra, A. (2020b). Chemistry of Plant–Microbe Interactions in Rhizosphere and Rhizoplane. *Ind. J. Pure & App Biosci. 8*(5), 11-19. doi: http://dx.doi.org/10.18782/2582-2845.8350.

Robinson, D. S. (1990). Food biochemistry and nutritional value. Longman scientific and technical publisher, NewYork. USA.

Salam, S. A., Javed, M. S., Toor, M. D., Adnan, M., Awais, M., Ud Din, M. M., Saeed, M. S., Rehman, F. ur., & Tampubolon, K. (2020). Influence of Industrial Waste Water on Soil and Plants: A Review, *Curr. Rese. Agri. Far. 1*(4), 19-23. doi: http://dx.doi.org/10.18782/2582-7146.120

Shaddel, S., Bakhtiary-Davijany, H., Kabbe, C., Dadgar, F., & Østerhus, S. W. (2019). Sustainable sewage sludge management: From current practices to emerging nutrient recovery technologies. *Sustainability, 11*(12), 3435.

Silva, J., Torres, P., & Madera, C. (2008). Reuso de aguas residuales domésticas en agricultura. Una revisión. *Agron. Colomb. 26*, 347–359.

Singh, N. K., & Dhar, D. W. (2006): Sewage effluent: a potential nutrient source for microalgae. *Proc. Indian Natl. Sci. Acad. 72*, 113-120.

Stumm, W., & Morgan, J. J. (1962). Stream pollution by algal nutrients12th

Annual Conference on San Engng. *Harvard Univ San Eng*. Reprint No. 45.

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature. 418*, 671–677.

Toor, M. D., Adnan, M., Javed, M. S., Habibah, U., Arshad, A., Din, M. M., & Ahmad, R. (2020). Foliar application of Zn: Best way to mitigate drought stress in plants; A review. *Int. J. Appl. Res*. *6*(8), 16-20.

Tyler, H. A., Buss, D. H., & Knowles, M. E. (1989). The Nutritional Importance of Vegetables. *Acta Hortic. 244*, 201-208. DOI: 10.17660/ActaHortic.1989.244.20.

Tzanakakis, V., Paranychianaki, N., & Angelakis, A. Soil as a wastewater treatment system: Historical development. *Water Sci. Technol. Water Suppl. 7*, 67–75.

Umaña, E. (2011). El reuso de aguas residuales para riego en un cultivo de maíz (Zea mays L.) una alternativa ambiental y productiva. *La. Calera. 7*(49), 22–26.

UN-WATER. (2007). Coping with water scarcity: Challenge of the twenty-first century, United Nations – Water.

Van-Dijk, K. C., Lesschen, J. P., & Oenema, O. (2016). Phosphorus flows and balances of the European Union Member States. *Sci. Total Environ. 542*, 1078–1093.

Wahid, F., Sharif, M., Ali, A., Fahad, S., Adnan, M., Noor, M. A., Mian, I. A., Khan, B. A., Alam, M., Saeed, M., Ilyas, M., Ullah, R., Ilahi, H., & Azeem, M. (2020). Plant-Microbes Interactions and Functions in Changing Climate. In book: Fahad, S., (eds) Environment, Climate, Plant and Vegetation Growth. Springer, Cham, pp. 397-419. https://doi.org/10.1007/978-3-030-49732-3_16

Waśkiewicz, A., Gładysz, O., Beszterda, M., & Goliński, P. (2016). Water stress and vegetable crops. In Water Stress and Crop Plants, P. Ahmad (Ed.). https://doi.org/10.1002/9781119054450.ch24.

WHO. (2006a). World Health Organization. WHO guidelines for the safe use of wastewater excreta and grey water. Vol. *1*. World Health Organization.

WHO. (2006b). WHO guidelines for the safe use of wastewater, excreta and grey water, *4*, Excreta and grey water use in agriculture. World Health Organization, Geneva, Switzerland.

Winpenny, J., Heinz, I., Koo-Oshima, S., Salgot, M., Collado, J., Hérnandez, F., & Torricelli, R. (2013). Reutilización del Agua en Agricultura: Beneficios para Todos; *124*, FAO: Rome, Italy.

Zada, L., Sajjad, M., Shafiullah, Rafiullah, Shah, F. A., Ali, F., Kamal, A., Ilahi, H., & Hidayat, K. (2021). Temporal variation in the physiochemical characterization of Malkandher River Waste Water. *Pure Appl. Biol. 10*(4), pp1104-1108. http://dx.doi.org/10.19045/bspab.2021.100115