Assessment of Quality, Fungal Population and Diversity, of Irrigation Water in Selected Areas of Minna, Niger State, Nigeria

Anthony Uzomasurerest[1], Tajudeen Muhammad Salaudeen[1]

1 Federal University of Technology, Minna

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

Water samples were collected at 3 slope positions (upper, middle and lower) from four locations practising irrigation agriculture in Minna as follows; Fadikwe, Mechanic village in keterin-gwari, Soje-A in kpakungu and Bali in Chanchaga and fitted to a Completely Randomized Design (CRD) having slope positions as replicates for each treatment. Water sampling, Physical and chemical properties and Fungi population and diversity were determined using standard methods. Data generated were subjected to Analysis of Variance (ANOVA) and means were separated using Least Significance Differences (LSD) and Duncan Multiple Range Test. Result obtained revealed that Chanchaga irrigation water recorded the highest fungi population of 1.6 x 10^7 CFU/ml why fungi diversity was the least at Chanchaga. The presence of *Geotrichum species* (2.33 x 10^6CFU/ml), *Candida tropicalis* (4.33 x 10^6CFU/ml) and *Torulopsis glabrata* (1.67 x 10^6CFU/ml) in water obtained from Mechanic village may be due to the presence of hydrocarbons in the oil polluting the water. They are potential degraders of crude oil hydrocarbons. They may therefore be responsible for the value of Biochemical Oxygen Demand of 261 mg/l recorded at Mechanic village. The Biochemical Oxygen Demand values of 342 mg/l and 360.00mg/l recorded at Fadikwe and Soje A respectively may be due to the presence of *Aspergillus niger.Aspergillus niger* is a utility biological indicator of level of degradation of pollutant. These values were however higher than the Food and Agriculture organisation (FAO) standards for irrigation water. Further studies should however be carried out to investigate the bioremediating potentials of the fungi species identified in irrigation water obtained from Chanchaga.

Anthony Ozoemenam Uzoma[1], **Larai Qudirat Abdullahi**[1], and **Tajudeen Muhammad Salaudeen**[2]

[1] *Department of Soil Science and Land Management, Federal University of Technology, Minna*

[2] *Department of Crop Production, Federal University of Technology, Minna*

[*] Correspondence: uzo_ozo@yahoo.com

Keywords: diversity, fungi, irrigation, population, quality, water.

Introduction

According to Agbabiaka (2012), earth is occupied by 70% of water, yet water is one of the scarcest resources considered in under-developing countries of the world for agriculture especially for irrigation. Water need of crops is a serious issue for the health and survival of both crops and microorganisms. Water is a vital component for the survival and proper functioning of living organisms. Most organisms, such as fungi must have access to water for biological, chemical and physiological activities (Gleick *et al.,* 1996). Wastewater, rain water, ground water and surface water are various sources of irrigation water. The easiest method of crop production is by rain water (Lie *et al.,* 2000). Ground water is relatively hygienically better than surface water for crop production (Ayers and Westcot, 1985). Waste water use in the developing countries has increased because it carries ample amounts of nutrients and is a dependable source of water supply (Hussein *et al*., 2001).

More than 10% population of the world consume foods produced by irrigation with wastewater (WHO, 2006). The percentage will be considerably higher among populations in low income countries with arid and semi-arid climates. Approximately 20 million hectares (irrigated land are about 7%) are irrigated with different types of wastewater (Scott *et al.,* 2004). Wastewaters are used directly and indirectly such as treated and untreated in developed and developing countries for irrigation purpose (WHO, 2006). It is used for irrigation at different levels of crop production (McGrath and Lane, 1989). Using waste water for irrigation is a crucial resource for meeting the disputes of speedily developing cities in sub-Sahara Africa for food production (FAO, 2008).

Wastewater irrigated vegetable production is the dominant agricultural practice in Minna during dry season. Because of limited sources of water in Minna metropolis such as rivers and streams, the farmers cultivate vegetables along the drainage channels for constant water supply to their vegetables. This practice of untreated wastewater irrigation has been in existence for some years. The primary crops grown are waterleaf, onions and *Ammarantus*. Vegetables are preferred because they grow within a short period of time and are more economically profitable (Ibrahim *et al.,* 2011).

In Minna, wastewater flows from different sources into the main drainage channel, containing refuses which may contaminate water used for irrigation or be a source of energy for heterotrophic mode of nutrition and microbial proliferation (Rousidou *et al*., 2010). Fungi which dominate a group of living organisms in diverse water bodies, lack chlorophyll and are heterotrophic in mode of nutrition, most of them being saprophyte. As saprophytes, they are present in surfaces of decaying plant and animal materials in water bodies such as ponds, rivers and streams (Sparrow, 1998; Stainer *et al*., 2000). Diseases caused by fungi constitute a huge problem to agriculture and health of consumers of agricultural product (Shehu *et al.,* 2014). *Aspergillus*, *Fusarium* and *Mucor* species are fungal pathogens identified to be affiliated with waste water used for irrigation. It is against this background that these present study was embarked on to uncover the potentials of different fungal flora associating with waste water used for irrigation in Minna.

Aim and objectives

The aim of study was to assess the quality, fungal population and diversity, of irrigation water in selected locations of Minna.

The objectives are to;

i. determine the fungal population of water used for irrigation as affected by location.
ii. determine the diversity of fungi as affected by location.
iii. correlate physicochemical properties of irrigation water with fungal population and diversity.

Materials and methods

Study area

The study areas were four different locations within Minna practicing irrigation agriculture on selected vegetable crops. Their GPS coordinates are as follows: Bari in Chanchaga (latitude 9^{0}32` 0.8” N and longitude $6^{0}$ 34` 53.9” E), Fadikpe (latitude 9^{0} 31` 53.3”N and longitude $6^{0}$ 35` 21.1”E), Mechanic village in keteren-gwari (latitude 9^{0} 36` 13.8” N longitude 6` 32` 15.8” E) and Soje A in kpakungu (latitude $9^{0}$ 35` 46.6” N and longitude 6^{0} 32` 10.4” E). Minna lies between latitude 9^{o} 41’ N longitude 6^{o} 30’ E and altitude 200-300m above the sea level. Temperature of Minna range from 19.05 to 36.85^{0}C. Rainfall in Minna varies from 0.0 to 693.0 (mm/month).

Soil, water and vegetation description

Minna soils are Alfisols derived from the basement complex rock. They are strongly brown to red or clay with often gravelly loamy sand. They range from shallow to very deep soils overlaying deeply weathered gneisses and magnetite, some are underlain by iron pan to varying depth. The freshwater bodies in Minna include Tagwai, and numerous tributaries and flood plains. (Sikoki *et al.,* 1992).vegetation cover in Minna is mainly grassland interspersed with shrubs and trees such as mango, shea butter, gmelina and neem.

Treatments and experimental design

The treatments are four locations in Minna using sewage water in irrigating selected vegetable crops. This locations are Fadikwe, Mechanic village in Keterin-gwari, Soje-A in Kpakungu and Bali in Chanchaga, while water was collected from 3 slope positions (upper, middle and lower) as 3 replicates and arranged in a Completely Randomized Design (CRD)

Water sampling and analysis

Irrigation water sampling was carried out between 08:00 and 10:00 hours in the morning at the time when farmers were irrigating (APHA-AWWA-WEF, 2001). Sterilized plastic bottles were used to collect water from three slope positions and intervals along the drainage channel. Water samples were also collected directly from the point where the hose were used by the farmers to channel the water for irrigation. The samples were stored in cold icebox and transported to the laboratory for analysis of fungi population and diversity within 24 hours. Physical, chemical and microbial studies were based on 'Standard Methods for Wastewater investigations (Ayer and Wescot 1985) as follows:

Chloride content by Argentometric titration method, Total Hardness by 0.01 M EDTA titrimetric method, Alkalinity by 0.02M H2S04 titration method, Electrical conductivity using conductivity meter, sulphate by Nephelometric method, Total Dissolved Solids (TDS) by gravimetric method, Nitrate-nitrogen by uv spectrophotometric method, Biochemical Oxygen Demand(BOD) by bottle incubation method, Chemical Oxygen Demand(COD) by titration with Ammonium sulphate solution, Heavy metals using inductive couple plasma mass 59 spectrometry (ICPMS), pH using potentiometric method, Fungi enumeration using pour plate method, fungi diversity using colours, growth forms and microscopy**.**

Data analysis

All data were subjected to analysis of variance (ANOVA) using statistical analysis system (SAS) version 9.0 and the means were separated using Least Significance Differences (LSD) at 5% level of probability. Correlation matrix was used to correlate fungi population with physicochemical properties of water.

Results and Discussion

Fungi colonies observed in irrigation water were not too different across locations practising irrigation in Minna. Apart from Aspergillus niger that was black, other spps. observed were averagely white to cream in colour (Table 1). Fungi are not photosynthetic but colour differentiations and microscopy are necessary for identification.

Table 1. Growth forms of Fungi species in the Macroculture

Species	Growth	Growth forms	Colour	Periphery	Hyphae
Geotrichum species	Quick, can be differentiated after few days	Initially yeast-like, later formation of aerial mycelium	White	Fine extentions	Septate with dichotomous ramification
Aspergillus Niger	Recognisable Within a few days	Velvety to flatly surface due to marked sporulation	Black	Fluffy radiating extentions, entire petri dish is filled after a few days	Septate
Torulopsis Candida	Cultures take several days to grow	Semi-glossy, smooth to rippled	Grey-white	smooth with a fringed border.	Occasional septate hyphae
Torulopsis Glabrata	produce invasive pseudohyphae under nitrogen limiting conditions on solid media and in addition forms invasive yeast cell	Smoothly demarcated, round colony	Cream	Smooth with protruded or budded border.	No hyphae
Alternaria species	Growth is rapid.	Radial mycelia	Olivaceous to gray to black woolly colonies	Fine radiating fringes	Conidiophores are erect, septate, and geniculate. Large brown, muriform conidia with beaks that are borne singly or in chains
Microsporum Audouinii	Moderately quick After 7 days slight fluff	Flat, fluffy disc, with spoke-like grooves and central button	Upper-side white to Grey-white and light brownish underside orange to reddish brown	Fine radiating extentions	Ramified and septate, usually quite straight
Candida Tropicalis	Grow rapidly and mature in 3 days	Initially flat to slightly Domed then slightly wrinkled	Colonies are gray to yellow matt	smooth and butyrous with a fringed border.	**z**Septate with plentiful pseudomycelia
Mucor pasillus	Quick growth in just a few days.	Long-fibered rough woolly network of hyphae	Initially white, later grey with numerous black dots	entire petri dish is filled after a few days	Sparsely septate or thick, non septate

Quality and fungi population of irrigation water were significantly affected by location while location only significantly affected the composition of *Altanaria spp* and *Microsporum audoninii* (Tables 2 and 3). Chanchaga irrigation water recorded the highest fungi population of 16.00 x10^6 CFU/ml (Table 3) probably due to its acidic pH of 3.6 (Table 2). Singh *et al.* (2006) demonstrated that fungi tolerates acidity and can proliferate in acidic medium. Chanchaga irrigation water recorded the least fungi diversity (Table 3) suggesting that its water was somehow unfit for fungi participation in organic matter mineralization. Levels of salts and solutes of Chanchaga water were lower in values than those of other locations (Table 2) probably as a result of the presence of *Alternaria species* and *Microsporum audouinii*. Surprisingly their presence did not reduce Biochemical Oxygen Demand (Table2) implying that organic matter mineralization was minimized or deterred. The low electrical conductivity recorded in Chanchaga irrigation water may be due to their low levels of nitrate (0.15 mg/l) and chloride (29.80 mg/l) (Table 2). This is consistent with the report of (Marwaha *et al*. 1998) who observed higher levels of electrical conductivity as a result of the presence of organic and inorganic substances and salts. Increase in biochemical oxygen demand observed in Chanchaga water (756.30 mg/l) (Table 2) was as a result of the depletion of dissolved oxygen with consequent adverse effects on fungi respiration (Jerin, 2011). This may partly explain why fungi diversity was the least at Chanchaga (Table 3). Cooke (1970) however observed that reduced fungal diversity (Table 3) may be as a result of high organic matter present. The presence of *Geotrichum species* (2.33 x 10^6 CFU/ml), *Candida tropicalis* (4.33 x 10^6 CFU/ml) and *Torulopsis glabrata* (1.67 x 10^6 CFU/ml) in water obtained from Mechanic village (Table 3) may be due to the presence of hydrocarbons in the oil polluting the water. Kumari and Abraham (2011) reported that these species were found to be potential degraders of crude oil hydrocarbons. They may therefore be responsible for the lowest value of BOD (261.00 mg/l) recorded at Mechanic village.

Table 2. Effect of location on physical and chemical properties of irrigation water

Treatment	EC (µmho/cm)	pH	(TDS) (mg/l)	Total hardness (Mg/l)	Total alkalinity (mg/l)	Chloride (mg/l)	SO_4^{2-} (mg/l)	NO_3 (mg/l)	BOD (mg/l)	COD (mg/l)	Pb (mg/l)	Cu (mg/l)	Fe (mg/l)
Chanchaga	0.00047^b	3.60^d	0.30^b	231.00^c	17.00^d	29.80^d	288.72^d	0.15^d	756.3^a	574.0^d	0.03^b	0.04^d	2.7^b
Soje A	0.0025^a	7.11^b	1.60^a	260.00^b	421.00^b	285.07^a	478.94^a	0.85^a	360.0^b	764.0^a	0.07^b	0.17^{ba}	2.9^b
Fadikwe	0.00047^b	6.7^c	0.30^b	184.00^d	132.50^c	74.48^c	383.35^b	0.40^b	342.0^b	584.0^b	0.14^a	0.37^a	6.2^a
mechanic village	0.00031^c	7.11^a	0.20^b	328.00^a	470.00^a	260.25^b	362.10^c	0.28^c	261.0^b	624.0^b	0.15^b	0.42^a	1.6^c
± SE	0.0093	0.02	0.03	4.04	3.11	0.86	2.67	0.01	85.47	39.55	0.01	0.07	0.3
TRT	**	**	**	**	**	**	**	**	*	NS	**	*	**

*** = highly significant, * = significant, NS = not significant*

Means with the same letter(s) in a column are not significantly different at P≤0.05 by DMRT

NB; EC= Electrical Conductivity, TDS= Total Dissolved Solids, SO_4^{2-} = Sulphate, $NO_{3=}$ Nitrate, BOD= Biochemical Oxygen Demand, COD= Chemical Oxygen Demand, Pb= Lead, Cu= Copper, Fe= Iron

Table 3. Effect of location on fungi population and diversity of water used for irrigation around Minna

Irrigation source	Fungi population (10^6 x CFU/ml)	Geotricum species (10^6 x CFU/ml)	Aspergillus niger (10^6 x CFU/ml)	Torulopsis Candida (10^6 x CFU/ml)	Torulopsis Glabrata (10^6 x CFU/ml)	Altanaria species (10^6 x CFU/ml)	Microsporum Audoninii (10^6 x CFU/ml)	Candida tropicalis (10^6 x CFU/ml)	Mucor pasillus (10^6 x CFU/ml)
Chanchaga	16^a	0.00^a	0.00^a	0.00^a	0.00^a	6.6^a	15.33^a	0.00^a	0.00^a
Soje A	2.33^b	0.33^a	1.33^a	0.33^a	0.33^a	0.00^b	0.00^b	0.00^a	0.00^a
Fadikpe	3.00^b	1.00^a	1.00^a	0.00^a	1.00^a	0.00^b	0.00^b	0.00^a	0.00^a
Mechanic village	13.33^a	2.33^a	0.00^a	0.00^a	1.67^a	0.00^b	0.00^b	4.33^a	5.00^a
SE	1.5	1.3	0.8	0.2	0.8	0.2	1.5	1.9	2.5
Trt	**	NS	NS	NS	NS	*	**	NS	NS

Treatment (Trt), highly significant (**), significant (*), Non significant (NS), Standard Error (SE)

The low BOD values of 342.00 mg/l and 360.00mg/l recorded at Fadikpe and Soje A respectively (Table 2) may be due to the presence of *Aspergillus niger.* This is consistent with the report of Rao, (2000) who reported the utility of*Aspergillus niger* as a biological indicator of level of degradation of pollutant.

Table 4. Correlation between fungi population, composition and physicochemical properties

	Fp	Geo	An	Tc	Tg	As	Ma	Ct	Mp
Ec	-0.16	0.313	0.048	-0.193	0.321	-0.57	-0.7	0.401	0.37
pH	-0.61	0.278	0.235	0.112	0.342	-0.77	-0.95	0.224	0.21
Tds	-0.60	-0.17	0.34	-0.104	-0.243	-0.23	-0.3	-0.23	-0.21
Th	0.398	0.267	-0.20	-0.41	0.261	-0.17	-0.21	0.472	0.44
Ta	-0.22	0.270	0.086	-0.203	0.281	-0.57	-0.7	0.358	0.33
Cl	-0.28	0.205	0.128	-0.237	0.203	-0.53	-0.66	0.282	0.264
$S0_4$	-0.80	0.020	0.389	0.010	0.055	-0.59	-0.73	-0.1	-0.07
$N0_3$	-0.77	-0.07	0.398	-0.004	-0.079	-0.45	-0.56	-0.2	-0.16
BOD	0.473	-0.50	-0.15	-0.396	-0.17	0.62	0.773	-0.16	-0.22
COD	-0.36	-0.28	0.223	-0.612	0.211	-0.28	-0.32	-0.01	-0.04
Pb	-0.18	0.53	0.013	0.341	0.464	-0.56	-0.69	0.213	0.34
Cu	-0.17	0.172	0.021	-0.260	0.690	-0.49	-0.59	0.235	0.27
Fe	-0.56	0.044	0.241	0.529	0.036	-0.17	-0.18	-0.44	-0.3

Fp= Fungi population, Geo=Geotrichum species, An =Aspergillus niger; Tc=Torulopsis candida, Tg= Torulopsis.glabrata, Ma=Microsporum audouinii, Ct =Candida tropicalis, Mp = Mucor pasillus, EC=Electrical conductivity; pH=Potential of hydrogen ion, Tds= Total dissolved solid, Th=Total hardness; Ta=Total alkalinity, Cl=Chloride, $S0_4$=Sulphate, $N0_3$=Nitrate, BOD=Biochemical oxygen demand, COD=Chemical oxygen demand, Pb=Lead Cu=Copper, Fe=iron

The result of the correlation analysis (Table 4) revealed that fungi population*Alternaria species* and *Microsporum audouinii* correlated positively with BOD implying that their presence increased BOD and may therefore not be useful in the bio-remediation of organic matter. Similarly, *Geotrichum species*, *Aspergillus niger, Torulopsis candida* and *Torulopsis glabrata correlated positively with* sulphate*, lead and iron implying that their presence increased these metals by being* unable to bio remediate them. On the other hand, *Altanaria species* and *Microsporum audonini* correlated negatively with all the salts and heavy metals indicating that they were able to bio-remediate all the salts and heavy metals compared to other fungi spps (Table 4), yet they were found only in chanchaga irrigation water while *Geotrichum species* and *Torulopsis glabrata* that correlated negatively with nitrates implying that they can utilize nitrates, were the most common across locations practising irrigation.

Conclusion

In conclusion, regardless of location, the highest but the least diverse fungi population (1.6 x10^7 CFU/ml) was found in Chanchaga. Most of the values of water properties observed in Chanchaga water were lower than values recommended by WHO and CPCB standard. The high BOD which is a reflection of high accumulation of organic materials in water is a call for bioremediation. Little is known about the bioremediation potentials of *Microsporum audouinii* and *Alternaria species* found in Chanchaga water. Hence the need for bioremediation with appropriate species of fungi. Soje A has the least but most diverse fungi population. Some of fungi species found in Soje A and mechanic village have been reported to have potentials for bioremediation. The resource-poor farmers can augment the use of this water by harvesting rain water into wells for irrigation during dry seasons. Further studies should however be carried out to establish or investigate the bio remediating potentials of the fungi species identified in irrigation water obtained from Chanchaga.

References

- Agbabiaka, T.O. (2012). Microbial and Physicochemical Assessment of Foma River, Ita-Nmo, Ilorin, Nigeria. An Important Source of Domestic Water in Ilorin Metropolis. *International Journal of Plant, Animal and Environmental Sciences.* 2(1): 209- 216.
- APHA – AWWA – WEF, (2001). *Standard Methods for the Examination of Water and Wastewater*, 22nd Edition, Washington DC.
- Ayers, R.S. and Westcot, D.W. (1985). Water quality for agriculture.
- Cooke, W. B. (1970). Fungi in the Lebanon sewage treatment plants and in Turtle Creek, Warren co., Ohio. *Mycopathology and Mycology*. 42: 89-111.
- CPCB. (1995). Pollution Control acts, rules and modifications. Central Pollution Control Board, New Delhi.
- FAO (Food and Agriculture Organization of the United Nations). (2008). Microbiological Hazards in Fresh Leafy Vegetables and Herbs Meeting Report. Microbiological Risk Assessment Series No. 14. Rome. pp 151.
- Gleick, P., Stephen H. S. (1996). Encyclopedia of climate and weather. Oxford University Press. pp 306-310.
- Hussain, I., Raschid, L., Hanjra, M.A., Marikar, F. and van-der-Hoek, W. (2001). A framework for analyzing socioeconomic health and environmental impacts of wastewater use in agriculture in developing countries. Battaramulla, Sri Lanka: International Water Management Institute.
- Ibrahim A.D, Hussaini H, Sani A, Aliero A.A. and Yakubu S.E. (2011). Volatile metabolite profiling to discriminate diseases of tomato fruit inoculated with three toxigenic fungal pathogens. *Research in Biotechnology.* 2 (3):14-22
- Jerin, S. (2011). Isolation of microbes, treatment of flavour effluent using native fungus, *Aspergillus species* and reuse of bio treated water for germination and growth of ornamental plant, *Chrysanthemum species*. Dissertation University of Madras.
- Kumari, M. and Abraham J. (2011). Biodegradation of diesel oil using yeast *Rhodosporidium toruloides. Research Journal of Environmental Toxicology*. 5 (6): 369-377.
- Lie, F., Cook, S., Geballe, G.T. and Burch, W.R. (2000). Rainwater harvesting agriculture. *Journal of the Human Environment.* 29(8): 477-483
- McGrath, S.P, Lane P.W (1989). An explanation for the apparent losses of metals in a long- term field experiment with

sewage sludge. Environmental Pollution. 60: 235-25.

- Rao, V. (2000). Microfungi and their diversity and distribution in polluted and non-polluted water bodies from an industrial area (Patancheru) in Hyderabad, and hrapradesh, India. *Journal of Aqua-Biology.* 15(11): 112-114.
- Rousidou, C. Papadopoulou, K. Zervakis, G. Singh B.K., Ehaliotis, C. and Karpouzas, D.G. (2010). Repeated application of diluted olive mill wastewater induces changes in the structure of the soil microbial community. *European Journal of Soil Biol*. 46(1):34–4
- Scott, C.A., Faruqui, N.I. and Raschid-Sally, L. (2004). Wastewater use in irrigated agriculture: Confronting the livelihood and environmental realities. ISBN 0851998232.
- Shehu, K. Muhammad, S. and Salau I.A. (2014*).* Fungi associated with fruit rot of tomato (*Solanum esculentum* Mill) in Sokoto. *American Journal of Research Communication*. ISSN: 2325407.
- Sikoki, F.D. and J. Van Der Veen. (1992). Aspect of water quality parameters and the potential for fish production of Shiroro dam reservour, Niger State. A paper presented at the National Conference of Aquatic Resources, Calabar.
- Singh, H. (2006). Mycoremediation: Fungal Bioremediation. Wiley-Interscience, New York, USA.
- Sparrow, F.K. (1998). *Aquatic Phycomycetes*. University of Michigan Press. 11-87.
- WHO, (2006). Guidelines for the safe use of wastewater, excreta and grey water: Wastewater use in agriculture. World Health Organization, Geneva, Switzerland. 2: 74-219.