EVALUATION OF SOME SELECTED SOIL PARAMETERS INFLUENCING WATER MANAGEMENT OF DIFFERENT TYPES OF SOILS IN GHANA: A CASE STUDY IN ASHANTI REGION

ADIYAH Fowzia[1], *AGYEMANG DUAHStella*[2], *FUCHS Marta* [1*]

1 Department of Soil Science and Agrochemistry, SzentIstvan University, Gödöllő.
2 Department of Plant Science, SzentIstvan University, Gödöllő.
* Corresponding author: fuchs.marta@gmail.com

Introduction

The movement of water in soils through infiltration and percolation is determined by the pore space and the structure of the soil. These soil characteristics are influenced by several physical and chemical soil parameters i.e. soil organic matter content, pH, cation exchange capacity and texture, which serve as important components that contribute to the type of pore space and structure of soils and in the long run affect water management of soils as well. Although water management of soils significantly determines soil fertility, the available water management related information is limited in Ghana. In our study the effect of four selected soil parameters (soil organic matter, pH, cation exchange capacity and texture) which have a major role in the development of water management properties were evaluated for five soil series types (Kumasi, Asuansi, Nta, Bekwai and Akumadan) of the Ashanti region of Ghana.

Based on our evaluation we concluded the water management properties of the topsoil of the of Asuansi series may be the best among the studied soil types of the Ashanti region because of the high SOC content, acceptable pH level, high CEC (CEC>24m.e/100g) and moderately to high amount of clay in its texture.

Literature

Water management is very important in plant growth, influencing carbon allocation, nutrient cycling and rate of photosynthesis (Schwab et al., 1996). Soil moisture affects evaporation and transpiration which regulates the climate. It also regulates the hydrological processes as groundwa- ter recharge, infiltration and overland flow (Saxton and Rawls, 2006).

Water management of soils is influenced by several physical and chemical soil parameters which modify the effects of environmental factors as climate, vegetation, and topography. In the following this paper provides an overview of four selected soil parameters (soil organic matter, pH, cation exchange capacity and texture) regarding their effect and significance in the development of water management properties in different soil types of the Ashanti region, Ghana.

Soil organic carbon(SOC)is about 58% of soil organic matter which includes biological materials, fresh plant residues both in and on the soil, living organisms, particulate matter, humus and inert substance (Gregorich *et al.,* 1994; Lorenz and Lal, 2005). The presence of soil organic carbon helps the soil to store and provide clean water for human and animals. SOC improves the water holding capacity of soils (Allen *et al.*, 2010) as it serves a binding agent for soil particles that are held together to form the structure, which enables water to move through easily (Mccauley et al., 2017). In addition to its role in forming and maintaining the structure it loosens the soil which increases the pore space allowing air and water to pass through easily (infiltration and percolation) (Saxton and Rawls, 2006). Soil organic matter furthermore can hold up to 20 times their weight in water as well (Reicosky, 2005), increasing the available water holding capacity of soils. The ability of SOC to prevent soil sealing through the loosening of soil and through the ability to hold water molecules, influences the reduction and prevention of erosion and surface run-off.

In general most active carbon cycle is found in the top soils in the Ashanti region (Allen et al., 2010; Batjes, 2014), SOM is concentrated in the (A horizon) of the top soils with highly leached sub soils (Obeng, 2000).

Soil texture refers to the proportion of sand, silt and clay sized particles that make up the mineral fraction of the soil. Soil texture has a big influence on water management properties of soils as it affects porosity and structure development and as a result it determines water holding capacity, infiltration, permeability and degree of erosion among others. Soil texture determines the rate at which water drains through a saturated soil; water moves more freely through sandy soils than it does through clayey soils.

Soil texture can limit the soil’s potential to sequester carbon, particularly by influencing carbon cycling processes mediated by soil biota(FAO, 2017). Thus differences in soil texture affects organic matter levels; organic matter breaks down faster in sandy soils as a result of more oxygen is available for decomposition than in fine-textured soils, hence small to moderate soil organic carbon content found in the sandy textured soils (Mccauley et al., 2017). Clay is able to decrease or slow done the turnover rates of organic matter through adsorption, aggregation and effectively increasing SOC content. Soil organic carbon is much higher and stable in soils with clay content hence micro-organisms tend to be more concentrated in these soils than in sandy soils (Kaiser *et al*, 1992).

Soil texture are highly drained in the Ashanti region as a result of the higher percentage of sand in all the soils (Obeng, 2000; Boateng, Yangyuoru and Maccarthy, 2003).

Soil pH effects water management due to its influence on soil structure and biodiversity.Soil pH in the studied Ashanti region are generally slightly to moderately acidic in the topsoil (pH 6.5 - 5.1)(Nuhu *et al.*, 2012). These soils are susceptible to leaching of soluble salts (such as chloride, nitrates, carbonates and sulphates), and organic and chemical solutes into the subsoils through water percolation when rainfall is high(Jones et al., 2013). The low to moderately amount of SOC in the soils also explains the low pH levels. The strong leaching in Ghana has resulted in the acidification and low pH of soils which has negative effect on soil structure, thus on water infiltration and water holding capacity.

*Cation Exchange Capacity*is determined by the colloid content (i.e. soil organic matter and clay minerals) of soils. Because a higher CEC usually indicates more clay and organic matter is present in the soil, high CEC soils generally have greater water holding capacity than low CEC soils (CUCE, 2007).

Soils under the forest zone of the Ashanti region are characterized in general with low activity clays which are more highly weathered and form kaolinite 1:1 clays (Owusu-Bennoah et al., 2000; Jones et al., 2013). Due to their reduced surface area, low activity clays have a lower capacity to retain and supply nutrients (CEC< 24cmol (+)/kg clay) and, depending upon the pH of the soil, supply phosphate, sulphate and nitrate, rather than base cations (Adu, 1992). According to Mccauley and Olson-Rutz (2017) clay with high CEC acts as a binding agent that adsorb more cations such as calcium or potassium than more silty or sandy soils.

Climatic conditions also strongly influences the water management of soils – both directly (through rainfall and temperature) and indirectly (by effecting soils forming processes as humification and leaching). In the tropics strong relationship was found between SOC, rainfall pattern and temperature(Burke *et al.*, 1989). Moderately to high rainfall annually increases organic carbon content in soil. Ghana lies in the tropics and its climate is classified under the equatorial savannah with dry winter and it has an annual temperature range of 11°C -18°C (Jones et al., 2013). The forest Ochro- sol which is found in the semi deciduous forest zone is characterized with a double rainfall regime with about 1400mm annually (Nuhu *et al.*, 2012). Higher temperatures decreases SOC as a result of increase decomposition rates(Burke *et al.*, 1989; Lorenz and Lal, 2005).

Vegetation influences SOC greatly. Many studies have shown the high percentage of SOC in the natural forest as against secondary forest, plantations against cultivated croplands, grasslands against secondary forest etc., where various and different SOC percentages have been recorded (Afrifa and Acquaye, 2010; Batjes, 2014; Congreves *et al.*, 2014; Söderström *et al.*, 2014; Bragança *et al.*, 2015) . Vegetation in this region falls under the semi deciduous forest zone, the vegetation cover has some natural forest, secondary forest, tree crops like cocoa, oil-palm, croplands and grasslands. Deforestation and forest degradation has contributed to reductions in the SOC content in these areas (Afrifa and Acquaye, 2010; Nuhu *et al.*, 2012).

In terms of *topography* they are moderately undulating to sloping and are generally good for food crops and tree crops (Owusu-Bennoah et al., 2000; Nuhu et al., 2012).

Materals and methods

Sampling site/location

The Ashanti Region is centrally **located** in the middle belt of **Ghana**. It lies between longitudes 0.15W and 2.25W, and latitudes 5.50N and 7.46N. It has a land size of 24,390sq km, which is about 10.2% of the land area of **Ghana**. The region in its nodal structure share common boundaries, to the north with BrongAhafo; to the south with Central Region, to the east with Eastern Region and to the west with Western Region. The studied region is endowed with water resources such as the river Tano, Lake Bosomtwe, Barikese dam, ground waters and streams. Major soil types of the region under Forest Ochrosols (semi deciduous forest zones) are classified as Acrisols, Alisols, Lixisols Nitisols, Ferralsols, and Plinthosols in the international WRB soil classification system (Obeng, 2000).

Data source, sampling procedure

Soil data used for this study were obtained from the database of the KwadasoAgric Research Institute located in Kumasi in the Ashanti region.

Soil organic matter, pH, particle size (texture), cation exchange capacity and base saturation parameters were selected in order to evaluate their effect on water management.

Various soil horizons with depth ranging from 0-30cmwere included in the study. Data for Akumadan, Kumasi, Nta, Bekwaiand Asuansi series were randomly selected for this review.

Selected soil types

Asuansi series is a very dark grey loam coarse granular friable soil. The surface soil ranges in texture from gritty loam to gritty clay and subsoils are also heavy textured (40-69% clay).This is underlain by subsoil containing mainly quartz gravel (about 15-25% by volume) in yellowishbrown clay matrix and its WRB correlation is Orthi-Ferric Achrisol.

*Nta series*has very poor water relationship. They are subject to water-logging in the rainy season because of high groundwater table (WRB correlation is GleyicArenosol). Inthe dry season they dry out rapidly because of the light texture (over 80% sand) in the top soil. Because of thesereasons they require controlled drainage and irrigation for continuous production of crops grown onthem. They are slightly acid (pH 6.5) in the top layer but strongly to very strongly acid immediatelybelow. Base saturation is low (30 -40%).

*Akumadan series*are well drained, red loams and clay loams developed in peneplain drifts. The profile consists from 30cm of very dark greyish brown silty loam grading into dark brown silty loam. Underlying this is a reddish brown clay loam subsoil usually 120-150cm or more thick. The WRB correlation is Ferric Acrisol.

*Kumasi series*are red, well drained, gravelly and gritty clay loams and clays developed over deeply weathered biotite granite with some muscovite on summit and upper slope sites (3-12%). The top soils in an undisturbed profile consist of about 8-20cm of very dark greyish brown to dark brown coarse sandy loams containing few fine ironstone concretions. These overlie an upper subsoil extending downwards to a depth of 43-70cm and consisting of reddish brown. WRB correlation is Orthic-Ferric Acrisol.

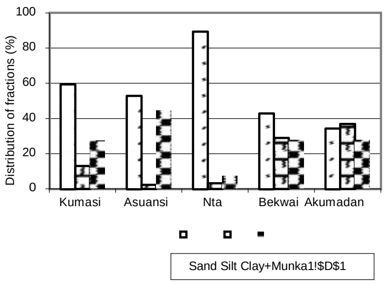
*Bekwai series*are red, well drained, gravelly and gritty clay loams and clays developed over deeply weathered biotite granite with some muscovite on summit and upper slope sites (3-12%). The top soils in an undisturbed profile consist of about 8-20cm of very dark greyish brown to dark brown coarse sandy loams containing few fine ironstone concretions. The WRB correlation is Orthi-Ferric Acrisol.

Statistical analysis

Data was statistically analyzed using MS Excel 2013 calculating for the averages and standard deviations of the various soil parameters (SOM, pH, particle size and CEC).

Results and Findings

The figures below shows the various soil textures (sand, silt and clay), pH levels, soil organic matter and cation exchange capacity in the topsoil (0-30 cm) of different soil types (Akumadan, Kumasi, Nta, Bekwai and Asuansi series) found in the Ashanti Region, Ghana.



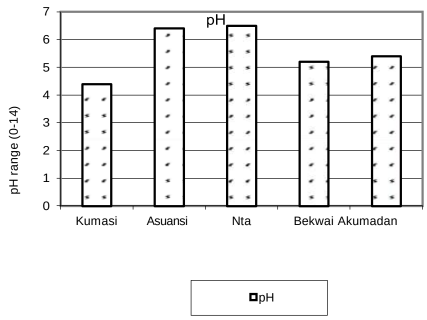
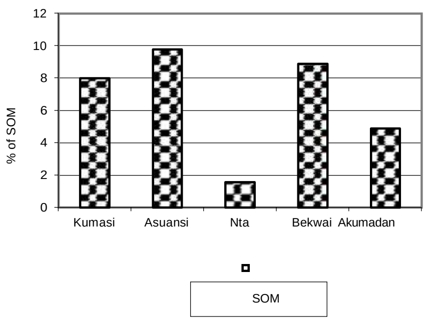


Figure 1. Texture of Soils *Figure 2*. pH of Soils
Figure (1) and (2) Soil Research Institute, Kwadaso, Ksi.



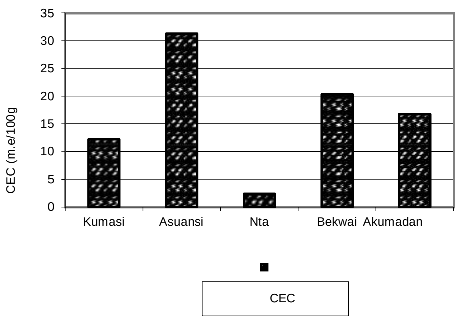


Figure 3. Soil Organic Matter contentFigure 4. Cation Exchange Capacity of soil types
Figure (3) and (4) Soil Reaseach Institute, Kwadaso, Ksi.

Figure 1.shows the proportion of sand, silt and clay sized particles of various soil types in Ashanti Region. Sand, silt and clay are all present in all soil types. Nta series (89mm) recorded significantly ($p<0.05$) the highest composition of sand. There were no significant ($p>0.05$) differences in sand compositions between Kumasi series (59.5mm), Asuansi series (53mm), Bekwai series (43mm) and Akumadan series (34.5mm). Asuansi series (2.4mm) recorded lowest level of silt. All soil composition had clay particles present in the soil with the highest values determined in case of the Asuansi series.

As coarser (sandy) soil texture results in lower water holding capacity, fast infiltration and high permeability, we can conclude that between the studied soil types Nta series shows poor water management possibilities.

Differences in soil texture also impacts organic matter levels; organic matter breaks down faster in sandy soils than in fine-textured soils, given similar environmental conditions, tillage and fertility management, because of a higher amount of oxygen available for decomposition in the light- textured sandy soils.

Figure 2.shows the pH levels of the soil types. All soil types fall within the range of 0-7 and therefore considered to be acidic. Acidification in a soil may cause degradation of soil structure, thus lower infiltration and water holding capacity which results in reduced plant growth.

Figure 3.shows percentage soil organic matter (SOM) in the (0-30cm) of the various soil types. Asuansi series (9.97%) recorded highest soil organic matter but had no significant ($p>0.05$) difference when compared to Bekwai series (8.89%) and Kumasi series (8.0%). Nta series (1.57%) recorded significantly ($p<0.05$) lower level of soil organic matter. Soil organic matter exerts a wide range of positive effects on soil physical and chemical properties, hence the higher the SOM and the deeper SOM rich horizon the more positive effects it has on the infiltration purification and water holding capacity.All the soils exibited high amount of SOM with the exception of Nta series hence it can be concluded that better effects can be expected for water management properties.

Figure 4.shows the cation exchange capacity present in the various soil types. Asuansi series (31.37m.e/100g) recorded significantly ($p<0.05$) highest cation capacity exchange. Nta series (2.4m.e/100g) had significantly (p.0.05) lowest level of cation exchange capacity. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients, provides a buffer against soil acidification, and increases water holding capacity.

Conclusion

Because of the limited water management related soil data of the studied Ashanti region we evaluated four selected physical and chemical soil properties which have significant effect on water management of soils. Based on our evaluation we concluded the water management properties of the topsoil of the Asuansi series may be the best among the studied soil types of the Ashanti region because of the high SOC content, acceptable pH level, high CEC (CEC>24m.e/100g) and moderately to high amount of clay in its texture. Infiltration, permeability and water holding capacities of this soil type can be effective.

Summary

Soil texture (sand, clay and loam), soil organic matter, soil pH and cation exchange capacity have an important relationship with the water holding capacity or porosity level of water in the various different soil types studied in this research which contributes greatly to environmental conditions, tillage and soil fertility management for proper utilization.

Keywords

Water management, soil texture, soil organic matter, pH, cation exchange capacity, soil series of Ghana

Acknowledgement

The authors would like to thank staff of Department of Soil Science and Agrochemistry, SzentIstvan University, Gödöllő for their support.

Reference

Adu S. V.:1992. *Soils of the Kumasi Region of Ghana*. Kwadaso-Kumasi: Soil Research Institute.

Afrifa A. A.-Acquaye S.:2010.Impact of shade and cocoa plant densities on soil organic carbon sequestration rates in a cocoa growing soil of Ghana', *African Journal of Environmental Science and Technology*, 4(9), pp. 621–624. doi: 10.4314/ajest.v4i9.71321.

Allen D. E.- Pringle M. J.- PageK. L.- DalalR. C.: 2010. 'A review of sampling designs for the measurement of soil organic carbon in Australian grazing lands', *Rangeland Journal*, 32(2), pp. 227–246. doi: 10.1071/RJ09043.

Batjes N. H.:2014. 'Total carbon and nitrogen in the soils of the world', *European Journal of Soil Science*, 65(1), pp. 10–21. doi: 10.1111/ejss.12114_2.

Boateng E. -Yangyuoru M. -Maccarthy D. S.:2003. Characterization of Soil-Water Retention with

Coarse Fragments in the Densu Basin of Ghana, pp. 31–46.
Braganç R. A. F.- Junior I. A. de.- Junior E. S. R.- Mendonça E. de. S.: 2015. Comparison of different methods for the determination of total organic carbon and humic substances in Brazilian soils, *Revista Ceres*, 62(March 2016), pp. 496–501. doi: 10.1590/0034- 737X201562050011.
Burke I. C.-Yonker M.- Parton W. J.- Cole C. V.- Flach K.- Schimel D. S.: 1989. Texture, climate, and cultivation effects on soil organic matter content in US grassland soils', *Soil Science Society of America Journal*, 53(3), pp. 800–805. doi: 10.2136/sssaj1989.03615995005300030029x.
Congreves, K. A.- Smith J. M.- Nemeth D. D.- Hooker D. C.- Van Eerd L. L.: 2014. Soil organic carbon and land use Processes and potential in Ontario's long-term agro-ecosystem research sites, *Canadian Journal of Soil Science*, 94(3), pp. 317–336. doi: 10.4141/cjss2013-094.
Cornell University Cooperative Extension (CUCE) (2007) Cation Exchange Capacity (CEC). Agronomy Fact Sheet Series # 22. Department of Crop and Soil Sciences, College of Agriculture and Life Sciences, Cornell University.
FAO, 2017. Soil Organic Carbon the Hidden Potential. FAO. doi: 10.1038/nrg2350.
Gregorich, E. G.- Carter M.R.- Angers D. A.- Monreall C. M.- EllertaB. H.: 1994. Towards a minimum data set to assess soil organic matter quality in agricultural soils', *Can. J. Soil Sci.*, 74, pp. 367–385.
Jones, A., Breuning-Madsen, H., Brossard, M., Dampha, A., Deckers, J., Dewitte, O., Gallali, T., Hallett, S., Jones, R., Kilasara, M., Le Roux, P., Michéli, E., Montanarella, L., Spaargaren, O., Thiombiano, L., Van Ranst, E., Yemefack, M., Zougmore, R., (eds.), 2013. Soil Atlas of Africa. European Commission, Publications Office of the European Union, Luxembourg. 176 pp. ISBN 978-92-79-26715-4, doi 10.2788/52319
Lorenz K.- Lal, R.: 2005 The Depth Distribution of Soil Organic Carbon in Relation to Land Use and Management and the Potential of Carbon Sequestration in Subsoil Horizons, Advances in Agronomy, 88(5), pp. 35–66. doi: 10.1016/S0065-2113(05)88002-2.
Mccauley A.- Jones C.- Olson-Rutz, K.: 2017 Soil pH and Organic Matter*Nutrient management* Module No.(4449–8), p. 16.
Nuhu R.- Mohammed M.- Satoshi T.- Nakamura S.: 2012 Indigenous Fertilizing Materials to Enhance Soil Productivity in Ghana*Soil Fertility Improvement and Integrated Nutrient Management A Global Perspective*, (May 2014). doi: 10.5772/27601.
Obeng H.: 2000. Selected Economic Issues: Soil Classification in Ghana, *Cepa*, (3), pp. 1–33. Owusu-
Bennoah E.-Awadzi T.W.- Boateng E.- Krogh L.- Breuning-Madsen H.- Borggaard O. K.: 2000. Soil Properties of a Toposequence in the Moist Semi Deciduous Forest Zone of Ghana.pdf', pp. 1–10.
Reicosky D. C.: 2005. Alternatives to mitigate the greenhouse effect: Emission control by carbon sequestration, Simpósio sobre Plantio direto e Meio ambiente; Seqüestro de carbono equalidade da agua, pp. 20–28, Anais, Foz do Iguaçu.
Saxton K. E.- Rawls, W. J.: 2006. Soil Water Characteristic Estimates by Texture and Organic Matter for Hydrologic Solutions, *Soil Science Society of America Journal*, 70(5), p. 1569. doi: 10.2136/sssaj2005.0117.
Schwab O. G.- Fangmeier D. D.- Elliot J. W.: 1996. Soil and Water Management Systems, p. 371.
SöderströmB.- Hedlund K.- Jackson L.- Kätterer T.- Lugato E.- Thomsen I. K.- JørgensenH. B.: 2014. What are the effects of agricultural management on soil organic carbon (S)C) stocks? A systematic review protocol', *Environmental Evidence*, 3(2), pp. 1–8.

Evaluation of some selected soil parameters influencing water management of different types of soils in ghana: a case study in ashanti region

Abstract

The movement of water in soils through infiltration and percolation is determined by the pore space and the structure of the soil. These soil characteristics are influenced by several physical and chemical soil parameters i.e. soil organic matter content, pH, cation exchange capacity and texture, which serve as important components that contribute to the type of pore space and structure of soils and in the long run affect water management of soils as well. Although water management of soils significantly determines soil fertility, the available water management related information is limited in Ghana. In our study the effect of four selected soil parameters (soil organic matter, pH, cation exchange capacity and texture) which have a major role in the development of water management properties were evaluated for five soil series types (Kumasi, Asuansi, Nta, Bekwai and Akumadan) of the Ashanti region of Ghana.

Based on our evaluation we concluded the water management properties of the topsoil of the of Asuansi series may be the best among the studied soil types of the Ashanti region because of the high SOC content, acceptable pH level, high CEC (CEC>24m.e/100g) and moderately to high amount of clay in its texture.

Soil texture, SOM, pH and CEC have an important relationship with water management in the various soil types reviewed which contributes greatly to soil fertility management.

Keywords:
Water management, soil texture, soil organic matter, pH, cation exchange capacity, soil series of Ghana

CLIMATE CHANGE ASSESSMENT AND ITS IMPACT ON EVAPOTRANSPIRATION AND IRRIGATION REQUIREMENT OF MAJOR CROPS IN DISTRICT FAISALABAD

Ahsan Raza[1], Vekerdy Zoltan[2*], Wai Yan Aung[3], Lubangakene Denish[4]*

1*Szent Istvan University, razaahsan878@gmail.com
2*Szent Istvan Univrsity andUniversity of Twente,vekerdy.zoltan@mkk.szie.hu

Abstract

Crop water requirement (CWR) depends upon many climatic parameters and any significant or even moderate change in these parameters by global warming can affect Evapotranspiration or CWR.In this study analysis and a comparison is done between past and future mean annualtemperature, mean monthly temperature, precipitation, reference evapotranspiration and crop water demands of major crops in Faisalabad District. Two climatic data sets were made as: Past thirty years (Base line): (1981 to 2010) and future thirty years: (2040 to 2069). CCSM4 (Community Climate System Model) General Circulation Model of Fifth Assessment Report(AR5) under Representative Con- centration Pathways (RCP 8.5) was used for future data. CROPWAT model version (8.0) was used to calculate CWR and reference evapotranspiration. Results showed that climate of Faisalabad regi- on is changing and will shift from semi-arid to dry region between 2040 and 2069. It is projected that there will be 2.6°C rise in mean annual temperature and 0.20mm/day in mean annual reference evapotranspiration between 2040 and 2069 according to AR5 under 8.5 RCP scenario. Total annual precipitation is expected to decrease by 67.6mm per years and change in mean monthly temperature was also observed for each month. Crop water requirement showed an increment of 6%, 6%, 6% and 8% for wheat, cotton, sugarcane and maize respectively in the time period of 2040-2069.

Introduction

Evapotranspiration (ET) is one of the most important parts of the hydrological cycle and is used in the estimationof the crop water requirement (CWR). There are other climatic parameters too, which have an effect on ET and thus on CWR. Any significant or even moderate change in these parameters by global warming can also affect ET or crop water demand. Climate change results in increment ofdry environmental conditions in the arid areas of the globe by rising reference evapo- transpiration. (Houerou and Le-Houerou, 1993).

Almost two-third of Pakistan belongs to the arid zone. Here, the ET rate is high as compared to other parts of the country and the level of ground water is shallow.An increase in average air tem- perature can cause loss of water resulting in increasing aridity. If the ET rate continues to increa- sethen the small dams and ponds etc. would dry up more quickly and fast. Pakistan satisfiesits water needs from the summer and winter rainfall and also from the melting of snow andthe glaciers in the high mountains. Due to the result of global warming, variabilityofthe summer rainfall and the mon- soon has considerably grewand glaciers are being melted more rapidly than observed earlier (Rasul, 2008).

Research Objectives

- To estimate future/possible crop water requirement under different climate change scenari- os.
- To estimate the effect of the climate change in the study area from the period of 1980 to 2010 and 2039 to 2069 in relation to the irrigation water requirement of major crops for a selected district.

Literature review

Ali and Adam (2007) investigated the response of evapotranspiration because of possible climatic changes at three different locations in Bangladesh. They predict 11 to 15% increment of total ET demand with an increase in maximum temperature (Tmax) by 20%. Marginal increment in ET could be observed with 10% increment in temperature alone with 10% decrease in bright sunshine hour (SH) and wind speed (WS). A 10 % increase in temperature along with 10% increase in sunshine hour, wind speed and 15% decrement in relative humidity (RH) could cause in 18.5% increase in annual ET.

Gondim et al. (2009) made an assessment based on future scenarios derived from PRECIS (Providing Regional Climates for Impacts Studies), using boundary conditions of the HadCM3 (Hadley Centre Coupled Model Version 3). The research concluded that due to higher temperature in future, there is a moderate evapotranspiration increment.

Yu et al. (2002) explored the climate change impacts on water resources in South Taiwan. The results show the increasing trend in temperature and several changes in the transition probabilities of daily precipitation occurrence. After this, the weather series for temperature and precipitation are generated by using the weather generator for the future. These weather series are used as input to rainfall-runoff model (HBV) to explore the changes in water resources in the future. The results indicate anincreasing trend of runoff in the wet season and a decrease in the dry season.

Saravanan.K and Saravanan. R (2014) examined the crop water requirement in the tank irrigation command area using CROPWAT 8.0. The study shows that reference evapotranspiration (ETo) varies from 3.67 to 6.42 mm/day and effective rainfall varies from 12.8 to 166.8 mm. The peak water requirement was 1.11 l/s/ha or 9.6 mm/day with an application efficiency of 70%.

Material and Method

Study area

The study was conducted at the command area of District Faisalabad, Punjab, Pakistan (Elevation: around 180 m above mean sea level, latitude: 31º25’52" N, longitude: 73º04’40" E). This study uses the meteorological data of the station of Faisalabad (in the distance of 50-100 km) since the climatic parameters do not significantly change with in this range. The climate of Faisalabad is semi-arid according to the Köppen-Geiger classification (BWh) with extreme conditions in both summer and winter, where winter is dry and cold and summer in hot and humid. The average maximum and minimum temperature is 40.5 °C and 26.9 °C in the month of June. Whereas, in January it is 19.4 °C and 4.1 °C respectively.

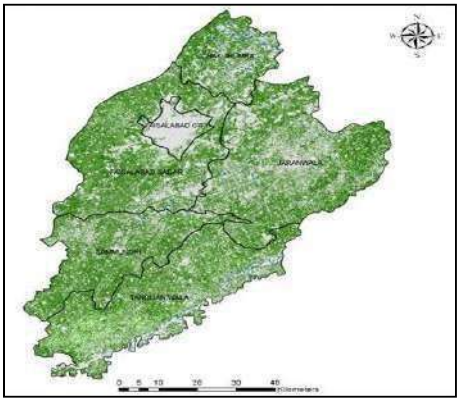


Figure 1: Faisalabad District
Source: Department of irrigation, Punjab

CROPWAT Model

CROPWAT model version 8.0 wasused in this research to calculate reference ET, crop ET and irrigation water requirements (IWR) for the study area. CROPWAT is a computer program that uses the FAO Penman Monteith model to calculate reference evapotranspiration (ETo),crop water requirements (CWR) and crop irrigation requirements (Smith, 1992)

Climatic Data

In this research following two climatic data sets are used:

1. Past thirty years (Base line): (1981 to 2010)
2. Future thirty years: (2040 to 2069)

Past climatic data (monthly maximum and minimum temperature, wind speed, humidity, daily sunshine hours) and rainfall for base line period is taken from Pakistan Metrological Department (PMD) for the years mentioned. Predicted climatic data from 2040 to 2069 is taken from GCM CCSM4 (Community Climate System Model) with RCPs 8.5.

Selected Crops

In this study, the following four major crops wereused to for defining their crop water requirements and irrigation water requirements. These are the most frequently grown crops in Faisalabad Division: cotton,wheat, maize and sugarcane.

Results and Discussion

In this chapter,the study results are discussed to assess the climatic changes and their possible impacts on the water requirement of four major crops grown in the study area.

Change in Climatic Parameters

Several climatic variables affect the ET, but in our study, the most important ones taken into account:thetemperature (representing the available energy) and the rainfall (representing the available water). The analysis focuses on the period of 1980-2010 as a baseline, and compares the prediction for the period of 2040-2069 by the CCSM4 (Community Climate System Model) GCM under RCPs 8.5 to it.

Temperature change

Table 1. shows the the comparison between past and future monthly average temperatures, whilst Figure 3 shows the annual means.. There is an increasing trendin both scenarios. The mean monthly temperautre increses from January to August and the decresestillDecember. This pattern does not change in the future scenario, but an overall increment of 2.6°C is predicted forthe future.

Month	Ave. Temp(2039-2069)	Ave. Temp(1981-2010)	Changes
	°C	°C	°C
January	14.27	11.82	2.45
February	16.77	14.81	1.96
March	21.64	19.93	1.71
April	27.77	26.22	1.54
May	33.89	31.48	2.41
June	36.05	33.49	2.56
July	35.40	32.25	3.15
August	35.40	31.56	3.85
Septembe	33.37	30.10	3.27
October	28.36	25.20	3.16
Novembe	21.82	19.11	2.71
Decembe	16.34	13.76	2.58
Average	26.76	24.15	2.61

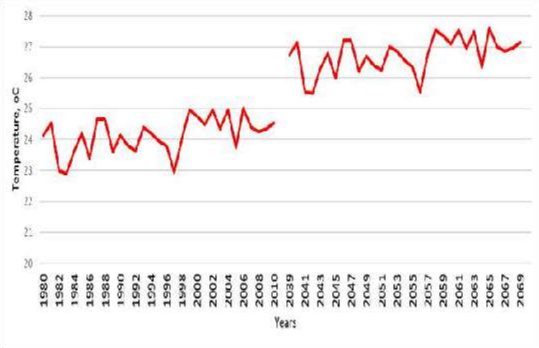


Table 1: Mean monthly temperature Figure 3: Mean annual temperature trend betwe betweenand their changes between 1981-20101981-2010 and 2040-2069 of District Faisalabadand 2040-206

Change in rainfall

Climate modelling results showthat the mean monthly rainfall decreasesin the monsoon period. It's clear from Figures 4 & 5 that the forecast predicts less rainfall in Faisalabad, or in other words, Faisalabad will movefrom semi-arid to dry conditions with a67 mm decrease in total annual rainfall.

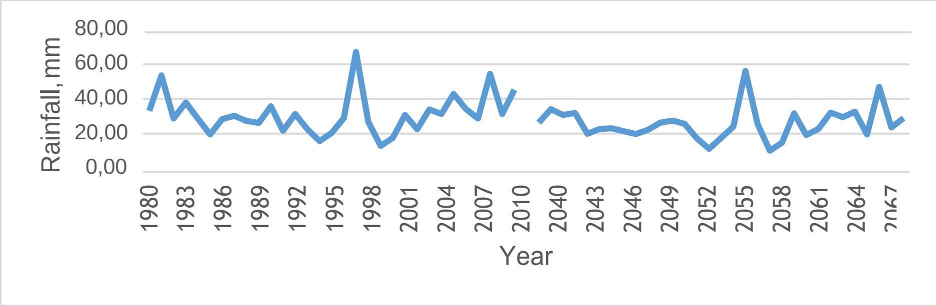


Figure 4: Mean monthly rainfall between 1981-2010 and 2039-2069

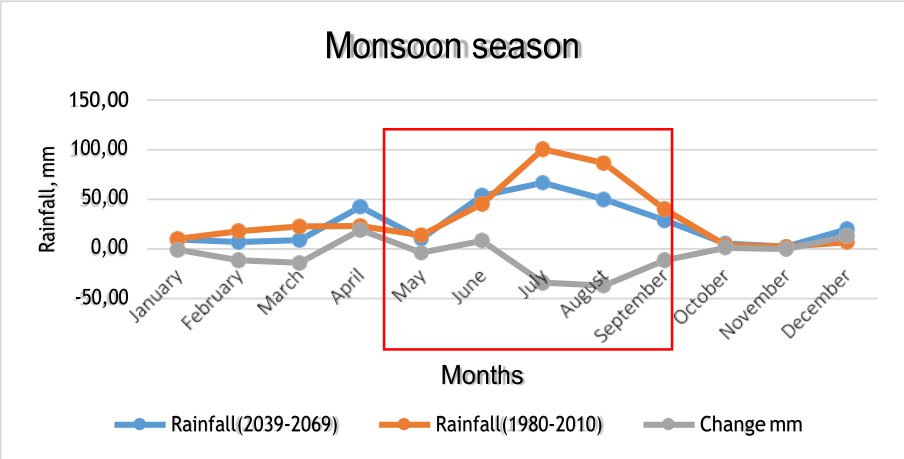


Figure5: mean monsoon rainfall between 1981-2010 and2039-2069

Change in reference evapotranspiration

Table 2 and Figure 6 shows the comparison ofpast and future daily mean reference evapotranspiration per month. The overall change in annual daily mean reference evapotranspiration between the past and future scenarios were predicted as+0.22 mm/day.

month	Eto(1980-2010)	Eto (2039-2069)	change
January	1.06	1.16	0.10
February	1.59	1.71	0.11
March	2.49	2.61	0.12
April	3.47	3.57	0.09
May	4.08	4.22	0.14
June	4.73	4.93	0.20
July	4.55	4.81	0.26
August	4.43	4.80	0.37
Septembe	3.95	4.29	0.34
October	2.89	3.15	0.26
Novembe	1.82	2.00	0.17
Decembe	1.20	1.31	0.11
	3.20	3.40	0.20

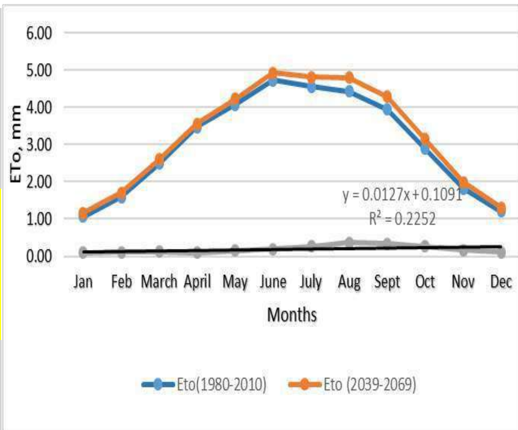


Table 2: Mean monthly ETo and their changesFigure 6 :Mean monthly reference evapotranspirationbetween 1981-2010&2040-2069in Faisalabadand their changes between 1981-2010 and 2040-2069in Faisalabad region

Change in Crop Water Requirement

Table 3 shows the percentage increment of crop evapotranspiration between 1981-2010 and 2040-2069 of the four major crops in the Faisalabad region.

Period/Crop		Sugarcane	Maize	Cotton	Wheat
1981-2010	mean annual ETcrop, mm	1123	269	678	171
2040-2069	mean annual ETcrop, mm	1196	292	721	182
Change	Percentage inrement	6%	8%	6%	6%

*Table 3:*Change ofcrop water requirement from 1981-2010 & 2040-2069

Irrigation Requirement

According to the modelled scenarios, the amount of precipitation in 2056 (732 mm) can result in sufficient availablity of effective rainfall, but not in 2053 and 2058 when commulative rainfall is modelled as 147 mm and 133 mm, respectively.(Fig: 7,8,9,10)

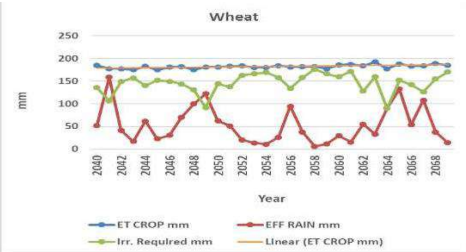


Fig 7: Crop water requireent of Wheat between 2041 to 2069

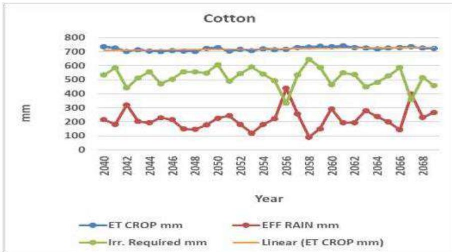


Fig 8: Crop water requireent of Cotton between 2041 to 2069

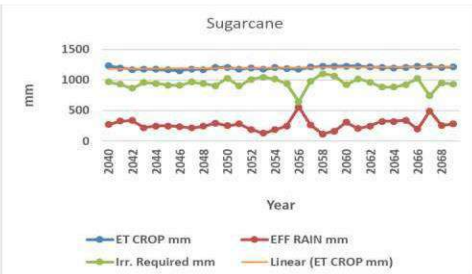


Fig 9: Crop water requireent of Sugarcan between 2041 to 2069

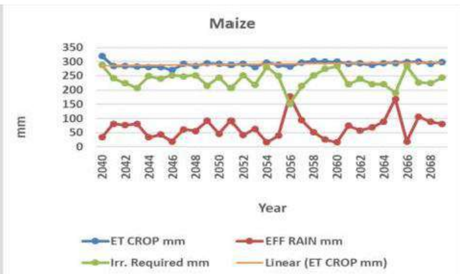


Fig 10: Crop water requireent of Maize between 2041 to 2069

Conclusions

Climate of the Faisalabad region is changing and mayshift from semi-arid to dry during the period of 2040 to 2069. It is observed that there will be about 2.6°C rise in mean annual temperature and 0.2 mm/day in annual mean ETo during 2040-2069 according to AR5 under 8.5 RCP scenario. Total annual precipitation is expected to decrease by

67 mm/y. Crop water requirement showed an increment of 6% for wheat, cotton and sugarcane and 8% for maize during 2040-2069.

Keywords

ET: Evapotranspiration; PMD:Pakistan metrological Department
CCSM4: Community Climate System Model; CWR:crop water requirement
ETo: Reference Evapotranspiration; RCP: Representative Concentration Pathways

References

Ali, M. H. and Adham, A. K. M. 2007. Impacts of climate change on crop water demand and its implication on water resources planning: Bangladesh perspective. Journal of Agrometerology, 9(1): 20-25.

Saravanan, K. and Saravanan, R. 2014. Determination of Water Requirements of Main crops in the Tank Irrigation Command area using CROPWAT 8.0. International Journal of Interdisciplinary and Multidisciplinary Studies (IJIMS). 1(5):266-272.

Gondim, R., Castro, M.A., Maia, A. and Evangelista, S. 2009. Climate change and irrigation water requirement at Jaguaribe river basin, semi-arid northeast of Brazil IOP conference series of earth and environmental science 6:1-2.

Yu, P.S., T.C. Yang, C.K. Wu. 2002. Impact of climate change on water resources in Southern Taiwan. J. Hydrol. 260 (1-4):161-175.

Houerou, H.N.le. and Le Houerou, H.N., 1993. Climatic changes and desertification. Secheresse. 4 (2): 95–111.

Rasul, G., Q. Dahe and Q.Z. Chaudhry, 2008. Global warming and melting glaciers along southern slopes of HKH ranges. Pakistan Journals of Meteorology, 5(9): 63-76.

FAO (Food and Agriculture Organization), 1992. CROPWAT, a computer programfor irrigation planning and management. Author, Smith M. Irrigation andDrainage Paper 46, Rome, Italy.

SUSTAINABLE WATER RESOURCE MANAGEMENT: PREREQUISITE FOR REALIZING KENYA'S VISION 2030

Amos W. Wawire [1,2],Erika Michéli [1],Adam Csorba [1]

1 SzentIstván University, Hungary
2 Karatina University, Kenya, wanjamos@gmail.com

1. Introduction

Water is a critical natural resource world over: it's the genesis of life, and the pillar for growth and development (WRMA, 2015). In fact, the United Nations Sustainable Development Goal (SDG) 6, "Sustainable management of water and sanitation for all" is the cornerstone to the realization of the rest of the SDGs, notably, No poverty (SDG1), No hunger (SDG2), Good health (SDG 3), life below water (SDG 14), and life on land (SDG 15) (Mugagga & Nabaasa, 2016). In the wake of climate change, water scarcity is global and real, particularly in the Sub-Saharan Africa.It is projected that African countries, are set to experience some of the worst effects of climate change by 2080, with devastating pressure on water resources and food production.Kenya is regarded as a water scarce country, with less than 650m^3 per capita against the recommended global benchmark of 1000m^3 (WRMA, 2015). About 90 percent of the country is classified either as arid or semi-arid. Further, rainfall patterns are becoming so increasingly unpredictable that even the traditionally more water-rich areas where water-intense economy has been on the increase are feeling the heat too. This development threatens the livelihoods of a huge population who depend almost entirely on rain-fed agriculture for food production, and casts doubt on the feasibility of Vision 2030 (Kenya'sdevelopment blueprint, which aims to transform the country into an industrialized middle-income economy by the year 2030. A guarantee to "safe and abundant supply of water is a key ingredient in attaining this goal. However, going by the current trends, Kenya is set to experience a 30 percent water shortage of the amount of water required to meet the country's demand in 2030. This anticipated deficit threatens sustainable growth, and thus calls for water management efforts.

2. The Water Situation at a Glance

Water is a major driver of human's economic and social expediency(FAO, 2011; Ngaira, 2009; Polidoro, et al., 2008). It is one of the most important ingredient of economic development, as well as a recipe for contention and conflicts between communities(UNEP, 2010). Whereas the images of the planet indicate huge amount of water, a large proportion of this water is salty and unsuitable for human consumption(UN, 2015; WBCSD, 2006). Only about 2.5 percent of the world's 1.4B km^3 volume of water is qualified as freshwater, fit for human consumption, while the rest (97.5%) is saltwater(NEPAD, 2006). Of this, less than one percent (0.3%) is found on the surface (lakes and rivers); 30.8 percent is ground water (including soil moisture swamp water and permafrost); 68.9 percent is water held in glaciers and permanent snow cover. At the continental distribution, Africa has the least proportion of fresh water (9 percent), while America has the lion's share of the global freshwater (45%), followed by Asia 28 percent, and Europe with 15 percent. Global water chal- lenges that the world is grappling with today can partly be attributed to this natural distribution and a myriad of anthropogenic factors (UNEP, 2010). Seasons of extremely high rainfall often inter- change with long dry spell.These uneven patterns of inequity, extremity, unreliability and variability have worsened in several areas due to effects of climate change, more so in regions inhabited by the resource poor and least resilient communities(Ashton, 2002; Donkor, 2003; Freitas, 2013; IPCC, 2014; Wolf, 2001). With most of her countries ranked as least developed, and with unprecedented population growth, Africa needs to utilize its water more judiciously than any other continent (AU, 2014).

Africa, and indeed Kenya, can however, take advantage of its enormous water resources such as lakes, rivers, swamps, underground aquifers, among others(Mugagga& Nabaasa, 2016). Con- trastingly, the situation in most of these African countries does not match this kind of endowment, a fact attributed largely to degradation, mismanagement and underutilization of these resources. The steadily increasing demand of this resource against the growing scarcity and shrinking temporal natural capabilities is an indicator of a looming crisis and a setback to Kenya's development agenda. The economic and social progress projected by vision 2030 will require enormous resource inputs than at present. To achieve this ambitious development plan, efficient and effective approaches to management of existing water resources, coupled with innovative strategies of harvesting rain and ground water, are critical.

Water Supply-Demand Gap

Kenya is regarded as a water scarce country, with less than 650m^3 per capita against the recommended global benchmark of 1000m^3(WRMA, 2015). Thissituation has been exacerbated by deforestation, wetlands encroachment, overgrazing and conversion of forests into settlement areas. These activities have significantly contributed to forests and vegetation degradation, and subsequent decrease in renewable water resources. Consequently, water levels in rivers, lakes, springs and aquifers, has been on sharp decline. The development of Kenya's water resource is about 20 percent (1.6 BCM per annum) of the 7.4 BCM surface water potential, and groundwater potential of 1.0 BCM per annum. Kenya has uneven distribution of water resources, with five major water towers: Mau Escarpment, Mt. Kenya, Aberdare Ranges, Cherengany Hills, and Mt. Elgon (Fig. 1b). On the other hand, more than 90% of the country experiences rainfall shortage, and is classified as either arid or semi-arid (ASALS) as shown in Fig. 1a.

Based on the current demand and the projected Kenya's development plans, the country could experience an estimated 31 percent gap between water demand the potentially available water supply by 2030, assuming a "business-as-usual" pathway of increased investment in water supply and a steadily projected increase in demand to achieve vision 2030 development goals. The national gap can be bridged if the supply side investments match development targets (WRG, 2015).

1/a

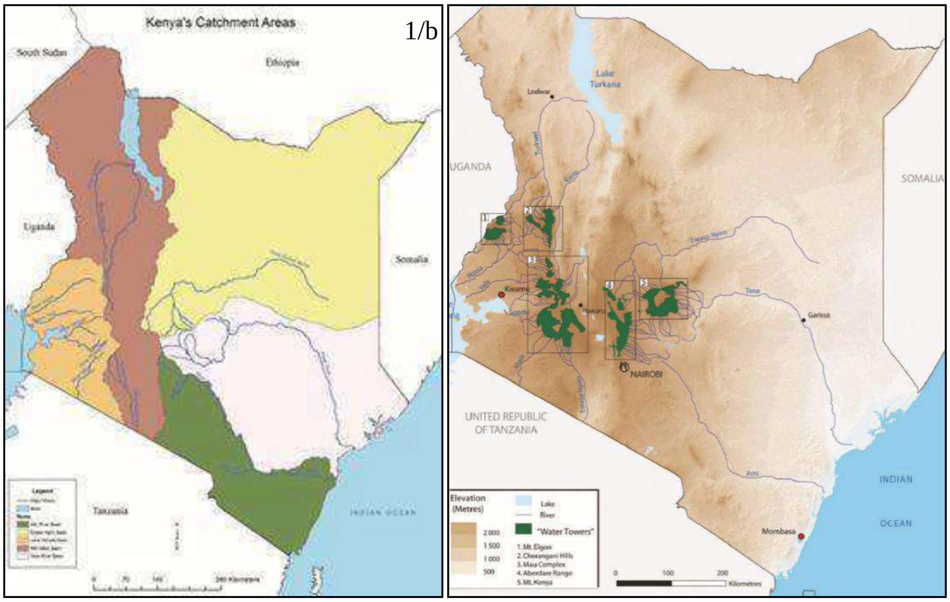


*Figure 1:*The major catchment areas (1/a) and the main water towers (1/b) of Kenya

Water resources and vision 2030

Vision 2030 is Kenya's development roadmap that aims to transform the country into a newly industrialized, middle-income country: providing a high quality of life to all its citizens by the year 2030 (WRG, 2015). The vision's specific goals are anchored on three(3) pillars: economic, social and political pillar. "Access to water and sanitation" is the goal on water and sanitationunder the social pillar. Management of water resources is critical in realizing the targets under the 3 pillars (Water Sector). For instance, water resource are linked to theVision's political pillar: the intercom- munity clashes have largely been influenced by access to natural resources, especially water. The achievements of the targets under health and tourism, which constitute the social pillar will heavily depend on water. Equally, infant and child mortality rates are partly influenced by access and quality of water. Vision 2030 outlines projects targeting water resources management: rehabilitation and protection of indigenous forests in the five water towers. Construction of 24 four medium sized multipurpose dams project aims at harnessing water resources, improve availability as well as quality countrywide.

Relationship between water resources and other economic and social sectors

There is a direct link between water and other sectors of the economy(UNEP, 2010), as demonstrated in Table 2.Developing and availing water resources is crucial for agricultural production and overall economic growth (FAO, 2011; UN DESA, 2015; WWAP, 2015).

Sector	Linkages
Tourism	• Resort cities, premium parks, niche products – These will require additional water and expansion of water and sanitation infrastructure • Wildlife – Kenya's wildlife, a key attraction to tourists, requires water for survival
Agriculture	• Irrigation – Development of irrigation will increase demand for water as more land is brought under cultivation • Livestock – Water demand in ASALs will be met by constructing water conservation structures (dams and water pans) and drilling of more boreholes
Wholesale and retail trade	• Modernization of new retail markets – District-based retail markets require water and sanitation services, as will new supermarket chains
Manufacturing	• Special Economic Zones – Manufacturing processes require water supply and waste water disposal systems. Agro-processing is one of the highest consumers of water • SMEs – SME parks will also consume additional water and require sanitation services.
Health	• Improved Health – Since about 80%of all communicable diseases are water-related, access to safe water and sanitation to households will be required to improve health standards.
Environment	• Degraded catchment areas – Degraded water resources will be reclaimed to boost supply • Pollution – Industrial effluents and agricultural chemicals affect water quality, increase cost of treatment and endanger lives
Governance	• Cohesive society – Equitable distribution of water resources will help establish a more cohesive society since lackof water has been a source of conflict in the past

(Source: Kenya Vision 2030)

Table 1. Example of linkages between water resources and other economic and social sectors

Challenges of water management

Climate variability and environmental degradation are the major challenges facingKenya's water resources. These have resulted into: catchment degradation, drying up of rivers, declining of lake levels, degradation of water quality, heavy siltation in dams (undermining their hydropower generation and water supply capacity), damaged infrastructures (roads, railway lines, bridges), and floods (Water Sector)

The most largely vulnerable catchments are Athi and Tana catchments.Catchment degradation leads to increased hydrological variability, i.e. increased risks of floods and droughts). Poor land use is among the huge contributors to catchment degradation (WRMA, 2015). Examples include cultivation on steep slopes, river banks, and lakeshores without substantial conservation mechanisms, clearing of forests (for agriculture, fuelwood and charcoal, and construction and building materials) and destruction of cut off drains. Population pressure triggers poor land utilization leading to increased soil erosion. Seasonal rivers are disappearing due to drought and poor management of irrigation systems; and discharge ofindustrial effluent into rivers has led to the loss of fish and other aquatic biodiversity. Other challenges includeinadequate data on water resources, competing demands, catchment degradation, water resources data and information generation, unstructured enforcement of water laws, temporal and spatial distribution of the resources, interference of negative politics and conflicts among water institutions (WRMA, 2015).Lack of sufficient and shrinking financial resources in the water sector is a significant challenge to water management. (WRG, 2015). The public perception that water being a God-given commodity should be free, has led to lack of willingness to pay for water, thus undermining the resource management efforts and result- ing into unsustainable utilization of the commodity. Increase in Non-Revenue Water (NRW) in Kenya (which currently accounts for 42 percent of water in the country) is a hindrance to sustaina- ble water institutions due to insufficient revenues to support the agencies functions.

Opportunities

Institutional and policy frameworks reforms present the greatest opportunity in water management. The private sector is increasingly responding to the growing water shortage in the country by organizing themselves in groups and identifying solutions for bridging the demand-supply gap through drilling of boreholes and distribution of water in the households. Further, the enactment of the water Act 2002 facilitated the decentralization of the water services to local water services providers (WSPS), and a new Water Act enacted in 2016 has further decentralized water services to the 47 Counties. Since then, various institutions have been set up including Water Services Regulatory board (WASREB) whose main mandate is to develop and enforce rules within the water sector to guarantee access to efficient, affordable and sustainable services.

Conclusion

As it has been demonstrated through the numerous reviewed literature, there is a direct link between water resources and development. Water conservation will go a long way in ensuring a sustainable development path. This paper has also shown how the three pillars (Economic, political, and social pillars) under which Kenya vision 2030 is anchored, are influenced by water management. The performance of the key sectors identified by vision 2030 as the drivers of Kenya's development agenda, namely, Agriculture, tourism, Wholesale and retail trade, manufacturing, health, environment and governance are highly hinged on water resources.

Summary

An overview of the water situation, has been presented in this paper. Some of the efforts by the government to sustainably manage water resources, including the policy and institutional frameworks, are highlighted. Challenges undermining water resource management efforts are analysed. Opportunities presented by various reforms and policy documents have been identified. Recommendations propose for more concerted and practical efforts, including increased financial investment, in management of water resources, as the key to the realization of Kenya's development agenda.

Keywords

Water resources management, Water, vison 2030, sustainable development goals; policy; Africa; Kenya.

Acknowledgements

We gratefully thank colleagues who constructively critiqued this work helping in improving the paper to its current form. Special gratitude to the Government of Hungary, through Stipendium Hungaricum program for the doctorate scholarship to the first author.

References

Ashton, P. (2002). Avoiding Conflicts over Africa's Water Resources. Ambio, 31(3), . 236–242.

AU. (2014). *The Africa Water Vision for 2025: Equitable and sustainable use o fwate rfor socioeconmic development. AddisAbaba.* Addis Ababa: African Union.

CCAA. (2006). *Climate change adaptation in Africa. Research and.*

Donkor, S. (2003). Development challenges of water resource management in Africa. *African Water Journal, Pilot Edition,* , 1–19.

FAO. (2011). *The state of the world's landand water resources for food and agriculture (SOLAW) – Managing systems at risk.* Rome and Earth scan,London.: Food and Agriculture Organization of United nations,.

Freitas, A. (2013). Water as a stress factor in sub-Saharan Africa. European Union Institute for Secuirty Studies,Paris.

IPCC. (2014). *ClimateChange 2014. Synthesis report: Approved summary for policy Makers. IPCC fifth Assessment synthesis Report. 1 November 2014.*

Kenya Vision 2030. (2007). *A Globally Competitive and Prosperous Kenya.* Nairobi, Kenya: Government press.

Mugagga, F., & Nabaasa, B. B. (2016). The centrality of water resources to the realization of Sustainable DevelopmentGoals(SDG). Areviewofpotentialsandconstraints on the Africancontinent. *InternationalSoilandWaterConservationResearch*, 215-223.

NEPAD. (2006). *Water in Africa. Management Options to Enhance Survival and Growth.*

Ngaira, J. K. (2009). Challenges of water resource management and food. *Journal of Geography and Regional Planning Vol. 2(4),* , pp. 097-103.

Polidoro, B. A., Livingstone, S. R., Carpenter, K. E., Hutchinson, B., Mast, B., Pilcher, N., & Valenti, S. (2008). Status of the world’s marinespecies. Gland,Switzerland.

UN. (2015). *The United Nations World Water Development Report 2015: Water For a Sustainable World. facts and figures.*

UNEP. (2010). *Africa Water Atlas. Division of Early warning and Assessment (DEWA).* . Nairobi, Kenya.: United Nations Environment Programme (UNEP).

Water Sector. (dátum nélk.). *Water sector.*

WBCSD. (2006). *Water: Facts and trends.* London: Earth print Limited.

Wolf, A. (2001). *Water, conflict andcooperation.InRuth.S. Meinzen -Dickand Mark.W.Rosegrant. Overcoming water scarcity and quality constraints. International Food Policy Research Institute,.* Washington, DC, USA.

WRG. (2015). *Water Resources in Kenya: Closing the Gap.* 2030 Water Resources Group (WRG).

WRMA. (2015). *Strengthening Regulations for Sustainable Water Resources Management In Kenya.* Nairobi: WATER RESOURCES MANAGEMENT AUTHORITY.

WWAP. (2015). *The United Nations World Water Development report 2015. Water for a sustainable world.* Paris, UNESCO: (2015). The United.

References

Ashton, P. (2002). Avoiding Conflicts over Africa's Water Resources. Ambio, 31(3), . 236–242.

AU. (2014). *The Africa Water Vision for 2025: Equitable and sustainable use o fwate rfor socioeconmic development. AddisAbaba.* Addis Ababa: African Union.

CCAA. (2006). *Climate change adaptation in Africa. Research and.*

Donkor, S. (2003). Development challenges of water resource management in Africa. *African Water Journal, Pilot Edition,* , 1–19.

FAO. (2011). *The state of the world's landand water resources for food and agriculture (SOLAW) – Managing systems at risk.* Rome and Earth scan,London.: Food and Agriculture Organization of United nations,.

Freitas, A. (2013). Water as a stress factor in sub-Saharan Africa. European Union Institute for Secuirty Studies,Paris.

IPCC. (2014). *ClimateChange 2014. Synthesis report: Approved summary for policy Makers. IPCC fifth Assessment synthesis Report. 1 November 2014.*

Kenya Vision 2030. (2007). *A Globally Competitive and Prosperous Kenya.* Nairobi, Kenya: Government press.

Mugagga, F., & Nabaasa, B. B. (2016). The centrality of water resources to the realization of Sustainable DevelopmentGoals(SDG). Areviewofpotentialsandconstraints on the Africancontinent. *InternationalSoilandWaterConservationResearch*, 215-223.

NEPAD. (2006). *Water in Africa. Management Options to Enhance Survival and Growth.*

Ngaira, J. K. (2009). Challenges of water resource management and food. *Journal of Geography and Regional Planning Vol. 2(4),* , pp. 097-103.

Polidoro, B. A., Livingstone, S. R., Carpenter, K. E., Hutchinson, B., Mast, B., Pilcher, N., & Valenti, S. (2008). Status of the world’s marinespecies. Gland,Switzerland.

UN. (2015). *The United Nations World Water Development Report 2015: Water For a Sustainable World. facts and figures.*

UNEP. (2010). *Africa Water Atlas. Division of Early warning and Assessment (DEWA).* . Nairobi, Kenya.: United Nations Environment Programme (UNEP).

Water Sector. (dátum nélk.). *Water sector.*

WBCSD. (2006). *Water: Facts and trends.* London: Earth print Limited.

Wolf, A. (2001). *Water, conflict andcooperation.InRuth.S. Meinzen -Dickand Mark.W.Rosegrant. Overcoming water scarcity and quality constraints. International Food Policy Research Institute,.* Washington, DC, USA.

WRG. (2015). *Water Resources in Kenya: Closing the Gap.* 2030 Water Resources Group (WRG).

WRMA. (2015). *Strengthening Regulations for Sustainable Water Resources Management In Kenya.* Nairobi: WATER RESOURCES MANAGEMENT AUTHORITY.

WWAP. (2015). *The United Nations World Water Development report 2015. Water for a sustainable world.* Paris, UNESCO: (2015). The United.

Sustainable Water Resource Management: Prerequisite for Realizing Kenya's Vision 2030

Abstract

Kenya is considered a water scarce country, with 647m^3 per capita against the United Nations rec- ommended benchmark of 1000m^3. This challenge has been compounded by increasing deforesta- tion, wetlands encroachment, overgrazing, increasing population, forest cover encroachment for human settlement and agriculture. This review paper presents an overview of water situation in Kenya, examines the extent to which water resources can catalyse the realization of the country's vision 2030. Specifically, the paper highlights the country's key water resources, water management strategies and adaptive mechanisms and explores the significance and potentials of water resources to Kenya's development plan by demonstrating their contributions and limitations. Further, the milestones realized, opportunities, challenges and risks are highlighted. It concludes with observa- tions and recommendations. Data were collected through review of online peer-reviewed articles, government policy papers, and compiled reports from research organizations. Strides made by the country in the management of water resources, including implementation of policy and institutional frameworks are evident. However, Climate change, poor water management, insufficient institu- tional funding are among the major challenges hindering sustainable water resource management efforts. A huge connection between water resources and development is evident from synthesised literature. Thus, proper management of water resources is critical for Kenya to achieve the antici- pated economic and social development envisaged in vision 2030.

Keywords

Water resources management, Water, vison 2030, sustainable development goals; food security; Africa; Kenya.

STUDY OF ELEMENTAL CONTENT OF LOW-COST ADSORBENTS FOR TREATMENT OF CONTAMINATED WATER

DurgVijayYadav– Márk Horváth– Gábor Halász

Department of Chemistry, SzIU, Gödöllő, Hungary, durgvijaycs0032@gmail.com

Abstract

In this study nine compost samples from several waste management plants in Hungary were studied. To achieve the aim of the study four objectives a) particle size fractionation of samples, b) determining the bulk density of samples, c) elemental content analysis and d) selection of prima optimal adsorbents were setup. Each sample was sorted and sieved into five different fraction “A” (Fraction Particle Size (FPS) ≤ 0.32 mm), “B” (0.32 mm < FPS ≤ 1.00 mm), “C” (1.00 mm < FPS ≤ 1.40 mm), “Rest” (FPS > 1.40 mm) and “Alien” (glass, plastic, brick, metal wire etc.). After calculating the Bulk density fractions were prepared for elemental content determination using microwave digestion. Elemental concentration (mg/l) of 9 elements (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn) of the fractions of samples were determined by inductively coupled plasma optical emission spectrometer, and elemental concentration (mg/kg) of the samples were calculated. FPS, bulk density and mg/kg concentration of elements were chosen as the three deciding parameter for selection of a prima op- timal low-cost adsorbent. The particle size fractions of the nine compost samples were evaluated according to these parameters.

Keywords: Adsorption, composts, low-cost adsorbents, and PotentiallyToxicElements.

1. Introduction

Potentially Toxic Elements (PTEs) present in contaminated water can be removed by technologies like chemical precipitation, ion-exchange, membrane filtration, coagulation and flocculation, electrochemical treatments, absorption and adsorption(Fu and Wang, 2011; Gour et al., 2016). Most of these technologies involves complex and expensive processes but adsorption (Heltai et al., 2011; Horváth et al., 2013)is the one which has been found to be most effective and economical technology(Babel, 2003; Bailey et al., 1999). Removal of PTEs using adsorption require selection of quality adsorbents(Kurniawan et al., 2006; Malik et al., 2016; Wan Ngah and Hanafiah, 2008). Adsorbents like activated carbon and carbon nanotubes are high quality adsorbents but very expensive(Barakat, 2011) because the methods required for preparation of samples are expensive. So, the aim of this study was to find out high quality low-cost adsorbents for removal of PTEs from contaminated water.

Agriculturalwastes, industrial by products(Demirbas, 2008), wastes and natural substances, peat moss, fly ash, clay, coal, chitosan and zeolites have been used as the low-cost adsorbents(Hegazi, 2013). This study was an attempt to find out a different kind of low-cost adsorbent so compost was used as low-cost adsorbent in this study. Nine compost samples (six green composts, two sewage sludge composts and one mushroom compost) from several waste management plants in Hungary were chosen for the study.Four objectives a) Particle size fractionation of the samples, b) Determining the bulk density of the fractions of samples, c) Elemental content analysis of the fractions of samples and d) Selection of the prima optimal adsorbents were setup for the ranking of fractions of samples as low-cost adsorbent from best to worst.

2. Material and Methods

Nine compost samples of three category (green compost, sewage sludge compost and mushroom compost) were used in this study. The green compost sampleswere collected from Sióagárd, Bonyhád, Felgyő, Polgárdi, Baja, and Keszthely.The sewage sludge compostswere collected from Nyíregyháza and Baja. There was a mushroomcompost, which was a mixture prepared from the samples collected from different locations so there is no fixed location written for it.

2.1 Sample preparation

Dried samples were sorted for removal of alien materials present in the samples. Hand sorting (Quek et al., 1998)was done for the removal of alien material. Sorted samples were sieved into five different fraction “A” (Fraction Particle Size (FPS) ≤ 0.32 mm), “B” (0.32 mm < FPS ≤ 1.00 mm), “C” (1.00 mm < FPS ≤ 1.40 mm), “Rest” (FPS > 1.40 mm) of particle size, and “Alien” materi- als.There was no size limit for the fraction Alien because aliens were the material which did not belong to the original compost material.Percentage particle size distribution of fractions of samples were calculated to know the effect of particle size of fraction on the way samples were handled and to be ranked as low-cost adsorbent.

2.2 Calculation of bulk density

Bulk density (BD) of a granular solid can be calculated as dry BD or wet BD depending on need of the study using following formulae-

$$\text{Dry BD}\,\square_{\square} = \frac{\square\square}{\square_{\square} + \square_{\square} + \square_{\square}} \quad \text{and} \qquad \text{eq (1)}$$

$$\text{Wet BD}\,\square_{\square} = \frac{\square\square + \square\square}{\square_{\square}} \qquad \text{eq (2)}$$

Where M_s is the mass of solid, M_l is mass of liquid,V_p, V_v and V_i are the particle volume, inter- particle void volume, and internal pore volume respectively. V_t in eq(2) is the total volume (volume of particles plus volume of liquid) because in this case liquid will occupy all the voids and pores. In this study dry BD of each fraction of samples were calculated without any compaction or consoli- dation.

2.3 Determination of elemental content

Fractions of samples were prepared for the elemental content determination aftermicrowave digestionwith HNO_3/H_2O_2 mixture in a CEM MARS5 apparatus.Elemental content of the digested fractions were measured using JobinYvonACTIVA-M inductively coupled plasma optical emission spectrometer (ICP-OES) with imaging charge coupled device (CCD) detection. Standard solutions were prepared fromUSA’s National Institute of Standards and Technology (NIST) recommended standards. Yttrium (1 mg/L) was used as internal standard.Concentration of9 elements (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn) was determined fromthe fractions of samples.

3. Results and Discussion

3.1 Fraction particle size

Particle size distribution of all the fractions of samples are given in Table1. The distribution shows the percentage of each fraction of samples naturally present after sorting and sieving a given weight of the samples. The value for sample 1A is 6.16% which means Green compost from Sióagárd was having 6.16% of the fraction with FPS ≤ 0.32 mm. Similarly sample5 had 69.04% of the fraction with FPS > 1.40 mm.

	1st compost	**2nd compost**	**3rd compost**	**4th compost**	**5th compost**	**6th compost**	**7th compost**	**8th compost**	**9th compost**
A	6.16%	5.70%	17.29%	19.61%	5.54%	20.73%	19.92%	6.53%	19.16%
B	25.28%	20.30%	34.64%	39.31%	12.17%	21.19%	24.87%	18.37%	21.77%
C	23.41%	12.62%	9.005	9.54%	10.84%	10.42%	11.36%	10.67%	10.03%
Rest	40.24%	53.00%	31.96%	23.945	69.04%	44.61%	34.26%	63.40%	44.37%
Alien	4.92%	8.37%	7.11%	7.60%	2.41%	3.05%	9.58%	1.02%	4.67%

*Table 1.*Percentage particle size distribution of fractions

Fraction 5Rest is the highest percentage of any fraction present in any sample. That gave sample5 an upper hand because smaller size particle could easily be prepared by simply grinding the larger particles. Amount of fraction 8Rest is the second highest with 63.40%. Samples were alienated into fractions of varying particle size to know the even or uneven distribution of particles in the sample. The more the even distribution of particles, easier was the sample to handle. So, the sample with higher amount of evenly distributed particle got higher rank based on particle size fractionation. For example, fraction 1B of sample1 got higher rank than fractions of sample8 while sample8 had the second highest percentage of fraction Rest.

3.2 Bulk density

Bulk density of the fraction of samples (Spl)used in this study was calculated usingeq(1). Calculated bulk densities are given in the Table2. Bulk density of fractions Alien is not given here because alien materials present in the sample did not have any role to play in the study other than in per- centage particle size distribution of samples so it was not calculated. Bulk densities in the range (0.5-0.7) were found more suitable for the study because in this range surface area of contact in the process of adsorption was found considerable maintaining the speed of filtration of contaminated water. Some of the values slightly above or below this range were also found outstanding. For example, the bulk density of fraction 5B was 0.44 g/cm^3 but it was ranked 2.

	Spl 1 g/cm^3	**Spl 2 g/cm^3**	**Spl 3 g/cm^3**	**Spl 4 g/cm^3**	**Spl 5 g/cm^3**	**Spl 6 g/cm^3**	**Spl 7 g/cm^3**	**Spl 8 g/cm^3**	**Spl 9 g/cm^3**
A	**0.77**	**0.71**	**0.90**	**0.64**	**0.63**	**0.85**	**0.69**	**0.75**	**0.72**
B	**0.63**	**0.57**	**0.70**	**0.53**	**0.44**	**0.63**	**0.56**	**0.65**	**0.55**
C	**0.50**	**0.51**	**0.52**	**0.29**	**0.37**	**0.53**	**0.52**	**0.59**	**0.49**
Rest	**0.56**	**0.56**	**0.50**	**0.25**	**0.44**	**0.54**	**0.47**	**0.62**	**0.53**

*Table 2.*Bulk densities of fractions of samples

Exceptionally, some of the values belonging to the range (0.5-0.7) did not performed well. For example, the bulk densities of the fractions 6C and 7C were 0.53 g/cm^3 and 0.52 g/cm^3 respectively but these were ranked 23 and 24. Reason for these exceptional performance of the fractions were the properties of samples like presence of clay in the compost, percentage fraction particle size distribu- tion and elemental content. Particle size distribution affected the ranking the most because with increasing particle size voids and porosity increases resulting in reduced contact surface area avai- lable for adsorption. That is why fraction Rest of almost all the sample got the bottom rank with the exception of 8C and 9C. Reason for 8C and 9C coming in the bottom was both Sampe8 and Samp- le9 were sewage sludge compost with alot of hard material present in the original composition of these samples which might hinder the process of adsorption using these samples.

3.3 Elemental content analysis

Concentrations of four elements Cr, Cu, Ni and Pb having major impact on the ranking of fractions of samples are given in the fig.1. Effect of elemental content on ranking of fractions is explained using concentrations in fraction A fig.1 and fraction C fig.2.

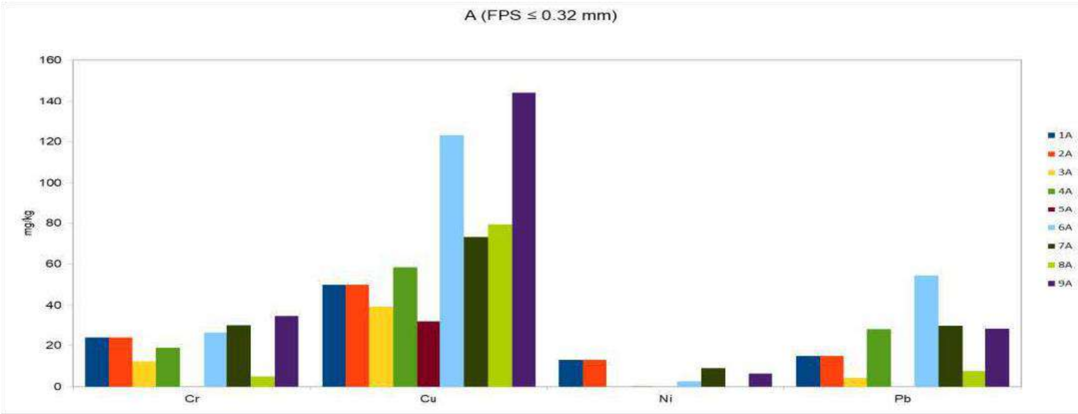


Figure 1. Concentration of Cr, Cu, Ni and Pb of fraction A of all the samples.

Copper was present in deciding amount (as shown in fig.1 and fig.2 for fractions A and C) in all the fractions of samples. Both fig.1 and fig.2 shows minimum value of copper in sample5 with 31.63 mg/kg for fraction A and 41.79 mg/kg for fraction C so the fractions of sample5 rightly got the highest rank.Presence of all other elements were uneven in the fractions but the element which af- fected the ranking the most was Cr. It was not present in both the fractions A and C of Sample5 which again justify the ranking. Cr was present in very little amount (3.94 mg/kg) in fraction 2C which is also in accordancewith the ranking. Similarly effect of other elements on fractions of samples were studied and fractions were ranked as shown in Table3.

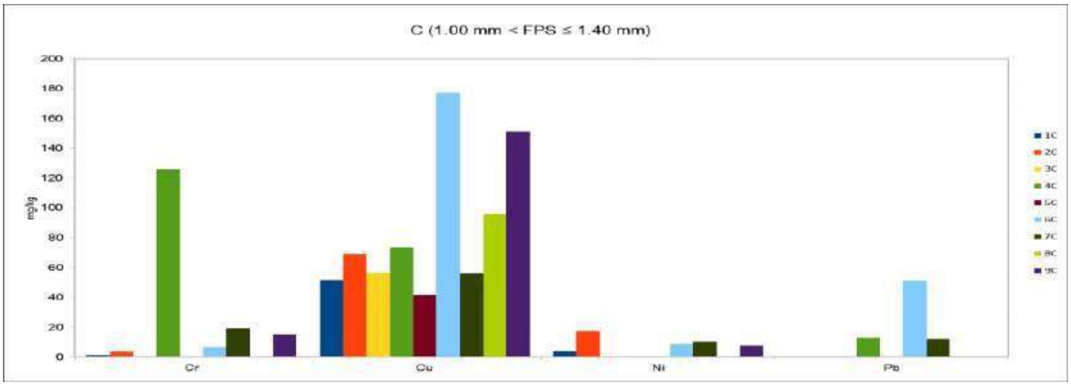


Figure 2. Concentration of Cr, Cu, Ni and Pb of fraction C of all the samples.

3.4 Selection of the prima optimal adsorbents

All the fractions of samples studied were ranked as low-cost adsorbents from best to worst based on their FPS, BD and concentration of elements (mg/kg)of the fraction weight. Table3 shows ranking of all the fractions. Based on the ranking in Table3, fractions of samples can easily be selected for adsorption of PTEs from contaminates water. Overall effect of all three parametersconsidered for the selection of prima optimal low-cost adsorbents shows that fraction 5A might be considered as a prima optimal low-cost adsorbents. Analysis of these parameters ranked fraction 5B as the second best low-cost adsorbent out of the fraction studied because concentration of most of the elements in fractions 5A and 5B were found to be very low.Constraint analysis of the fraction particle size, bulk density and concentration of elements ranked fraction 9Rest as the worst low-cost adsorbent. It was mostly because of the bigger particle size of this fraction.

Rank	Fraction	Rank	Fraction	Rank	Fraction	Rank	Fraction
1	5A	**10**	1A	**19**	4A	**28**	2 Rest
2	5B	**11**	3C	**20**	6A	**29**	3 Rest
3	1B	**12**	2A	**21**	9A	**30**	4 Rest
4	2B	**13**	8B	**22**	4C	**31**	8C
5	5C	**14**	3A	**23**	6C	**32**	6 Rest
6	3B	**15**	8A	**24**	7C	**33**	9C
7	4B	**16**	7B	**25**	7A	**34**	7 Rest
8	2C	**17**	6B	**26**	5 Rest	**35**	8 Rest
9	1C	**18**	9B	**27**	1 Rest	**36**	9Rest

Table 3. Ranking of fractions of samples

4. Conclusion

Fractions of samples studied were ranked as prima optimal low-cost adsorbent based on their FPS, bulk density and mass by mass concentration of the elements. Elemental analysis of the fractions showed that none of the compost sample considered for the study contained PTEs in concentration above the Hungarian limit for agricultural use. This result confirmed that all thirty six (excluding nine Aliens) fractions from nine compost samples falls under the category of low-cost adsorbents. Fraction particle size and bulk density of fractions were found well within the limits for fractions to be considered as adsorbent for contaminated water. Results of this study are useful for choosing the prima optimal low-cost adsorbents for treatment of contaminated water using bio-filtration.

Acknowledgments

This work has been kindly supported by the StipendiumHungaricum grant No. 500091 of the Government of Hungary.

References

Babel, S., 2003. Low-cost adsorbents for heavy metals uptake from contaminated water: a review. J. Hazard. Mater. 97, 219–243. doi:10.1016/S0304-3894(02)00263-7

Bailey, S.E., Olin, T.J., Bricka, R.M., Adrian, D.D., 1999. a Review of Potentially Low-Cost Sorbents for Heavy Metals 33.

Barakat, M.A., 2011. New trends in removing heavy metals from industrial wastewater. Arab. J. Chem. 4, 361–377. doi:10.1016/j.arabjc.2010.07.019

Demirbas, A., 2008. Heavy metal adsorption onto agro-based waste materials: A review. J. Hazard. Mater. 157, 220–229. doi:10.1016/j.jhazmat.2008.01.024

Fu, F., Wang, Q., 2011. Removal of heavy metal ions from wastewaters: A review. J. Environ. Manage. 92, 407–418. doi:10.1016/j.jenvman.2010.11.011

Gour, A., Sharma, A.K., Sharma, S., 2016. Removal of lead from aqueous solution using low cost adsorbents : A Review 2, 178–182.

Hegazi, H.A., 2013. Removal of heavy metals from wastewater using agricultural and industrial wastes as adsorbents. HBRC J. 9, 276–282. doi:10.1016/j.hbrcj.2013.08.004

Heltai, G., Remeteiová, D., Horváth, M., Széles, E., Halász, G., Fekete, I., Flórián, K., 2011. Various fractionation procedures in study of heavy metals mobility in the environment. Ecol. Chem. Eng. S 18.

Horváth, M., Halász, G., Kucanová, E., Kuciková, B., Fekete, I., Remeteiová, D., Heltai, G., Flórián, K., 2013. Sequential extraction studies on aquatic sediment and biofilm samples for the assessment of heavy metal mobility. Microchem. J. 107, 121–125. doi:10.1016/j.microc.2012.05.024

Kurniawan, T.A., Chan, G.Y.S., Lo, W. hung, Babel, S., 2006. Comparisons of low-cost adsorbents for treating wastewaters laden with heavy metals. Sci. Total Environ. 366, 409–426. doi:10.1016/j.scitotenv.2005.10.001

Malik, D.S., Jain, C.K., Yadav, A.K., 2016. Removal of heavy metals from emerging cellulosic low-cost adsorbents: a review. Appl. Water Sci. doi:10.1007/s13201-016-0401-8

Quek, S.Y., Wase, D.A.J., Forster, C.F., 1998. The use of sago waste for the sorption of lead and copper. Water SA 24, 251–256.

Wan Ngah, W.S., Hanafiah, M.A.K.M., 2008. Removal of heavy metal ions from wastewater by chemically modified plant wastes as adsorbents: A review. Bioresour. Technol. 99, 3935–3948. doi:10.1016/j.biortech.2007.06.011

SOIL CONSERVATION AND NATURAL WATER RESERVOIR: A BRAZILIAN STUDY CASE

Gelsleichter, Yuri [1] – Michelí, Erika[2]

1,2 Szent István University, 1yuriplanta@gmail.com ,2micheli.erika@mkk.szie.hu

Introduction

Water is fundamental for life. Water cycle is the water movement from one pool to the next one. Frequency and distribution of precipitation is one regulator of this cycle. Water as a source is stored in the rocks underground. The infiltration rate capacity is regulated by soil type, soil cover and use. The aim of this study is present the role of the soils of Itatiaia National Park in the dynamics of water distribution in the downstream areas and the relation with anthropogenic factors.

Itatiaia National Park

Itatiaia National Park (INP) located by (22o 15'e 22o 30'S; 44o 30'e 44o 45'W), in the border of Rio de Janeiro and Minas Gerais states, as demonstrated in the figure 1, was the first national park created in Brazil, by the June of 1937. In 1982 the area was increased from 11.943 hectares to 28.00 hectares. The INP elevation range from 390 to 2.791,55 m. The 2.000 m line split the INP in low and high part where the high part correspond to 60%. This elevation ranges implies in changes of climate and vegetation. Above 1.600 m, in general, occurs the Cwb Köppen (1948) climate, characterized by wet and dry seasons, this last occurs one to three month per year. The other parts of INP is classified as Cpb, the condition drives to a light summer and low temperatures during the winter, reaching negative degrees. Scarped relief promotes rain by the orographic effect (BARRETO et al., 2013).

Among the steep mountains and their shallow soils and rock outcrops, flat areas has more developed soils, as figures 2-3, with high organic content in general represented by figures 4-5. Some areas has waterlogging and high undecomposed organic material accumulation.

INP water supply

The northern river springs are converging to the Paraná river watershed that is going all the way down to the Atlantic ocean by the border of Uruguay and Argentina. While the Northeast are flo- wing to the Minas Gerais state. The region also concentrate springs that are supplying water in the south-southwest directions, for most part of Rio de Janeiro state (BARRETO et al., 2013).

Soil Functions and Water

Besides food production, Soil Organic Carbon (SOC) storage, water storage and water renewability can be assimilated as main functions among the Physical, Chemical, Biological and Ecological aspects. To keep the water retention and control tolerance to drought, is essential the maintenance of SOC threshold above 1,5-2,0% in the rootzone (LAL, 2016).

INP Threats

The area contains around 40 endemic vegetation species (AXIMOFF et al., 2014). The high part is mostly occupied by grassland, as figures 2-3-4-5, after dry season this vegetation is highly susceptible to fire. Along 36 years were registered 323 fire episodes, caused mainly by antropic influence (AXIMOFF et al., 2011).

After fire the exposure of soil tends to increase the erosion. Another factor that cause soil exposure and erosion is the uncontrolled use of the tracks by visitors.

Materials and methods

To understand the SOC composition of INP, soils were sampled by conditioned Latin hypercube sampling (cLHS), 90 profiles were selected. As demonstrated by figure 6. In the sequence they were briefly classified in the field according the Brazilian Soil Classification System (SiBCS). In the laboratory phase, SOC were measured by dry combustion method.

A set of maps were composed to cognize the relevance of the area. SRTM and raster data were acquired from www.earthexplorer.usgs.gov and www.naturalearthdata.com. Shapefiles from Centers for Disease Control and Prevention and Brazilian Institute of Geography and Statistics (IBGE). Software used was QGIS Development Team (2009), under GNU/Linux platform.

Results and Discussion

According to the soil classification, is estimated 45% of organic soils following the SiBCS. The area is presenting high quantities of carbon in the soil for tropical standards. Also is a considerable pool of SOC. Besides waterlogging areas, SOC is mostly preserved by the low temperatures. According to Lal, (2016) SOC is related to the water retention.

The significance of INP, among others, is presented by the influence on the composition of the Paraná river as demonstrated in the figure 7, and the supplying water to the Rio de Janeiro State. The region is replete of rivers and drainage channels as observed in the figures 1-8.

Tracks are spread in the INP area, they represented in the figure 6, and example of erosion caused by a track can be observed in the figure 4.

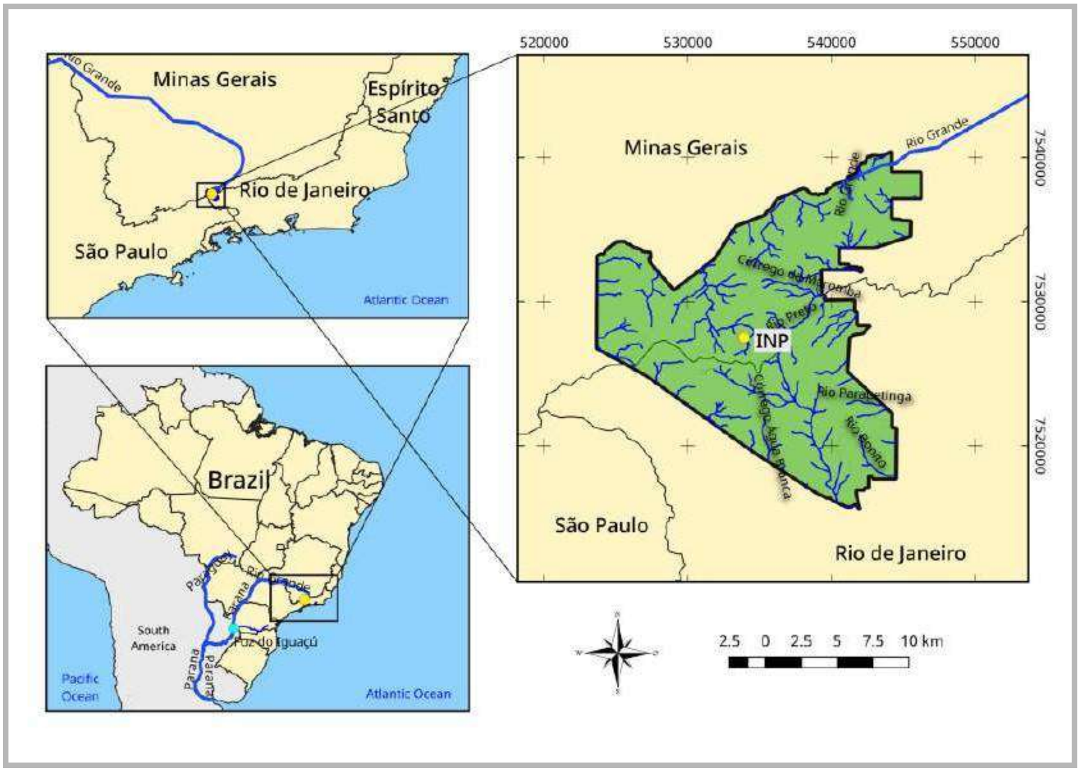


Figure 1: Location of INP.

Figure 2: Flat areas and vegetation.

Figure 3: Flat areas.

Figure 4: Soils of INP.

Figure 5: Soils of INP.

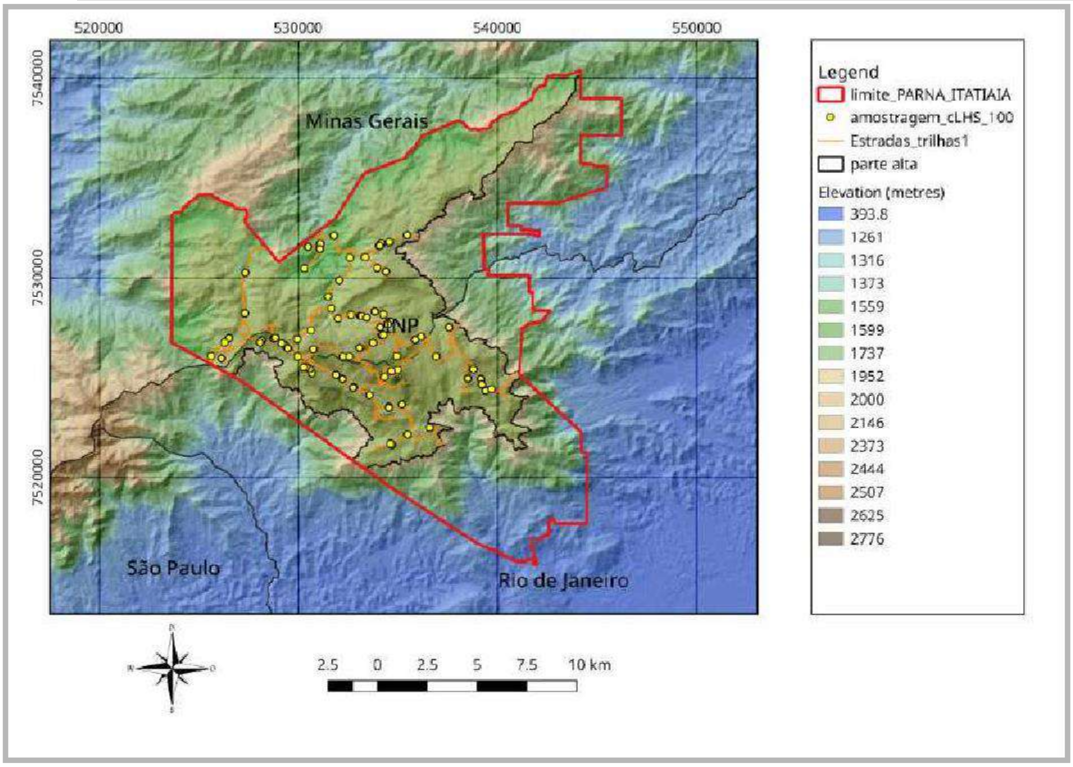


Figure 6: Tracks and soil sampling points.

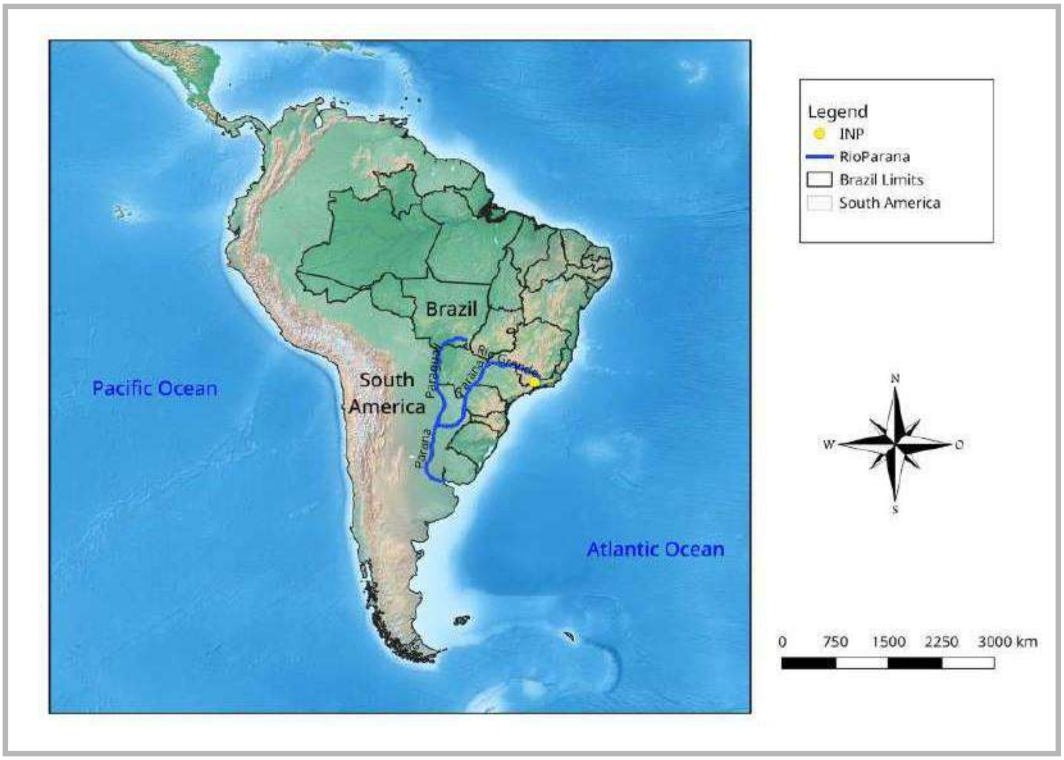


Figure 7: Paraná river.

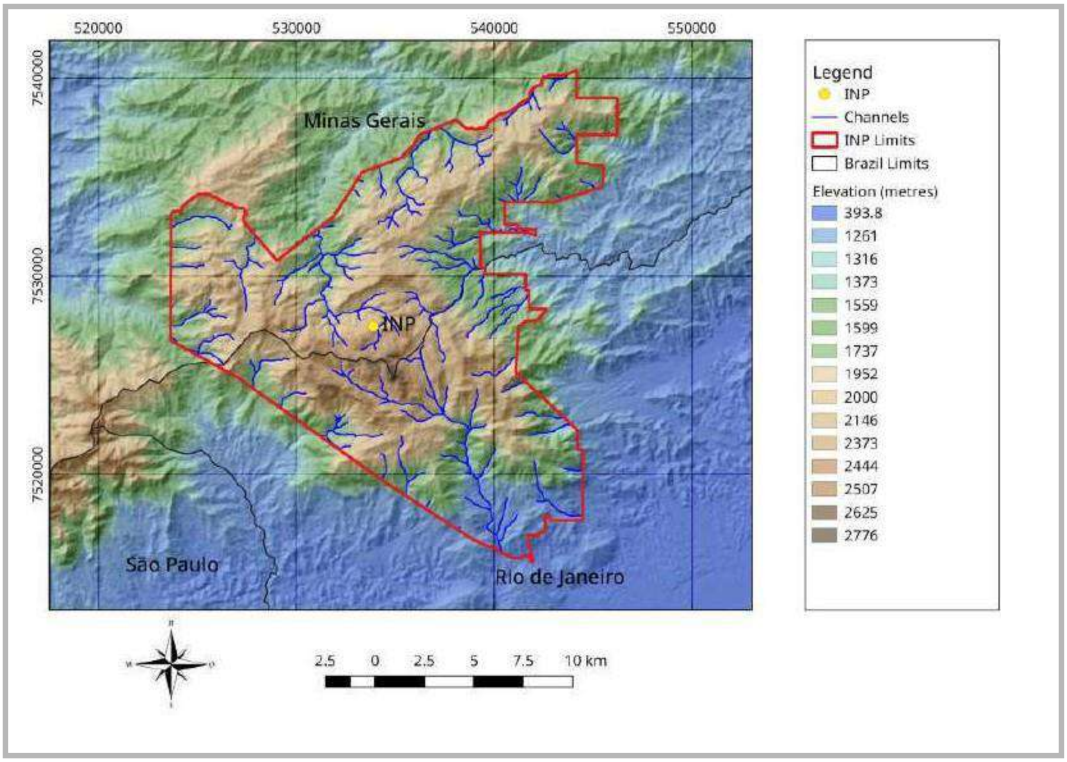


Figure 8: Drainage channels of INP.

Conclusions

The INP has fundamental importance for the water supply and the ecological services. Incorporation and storage of carbon is a contribution for climate stabilization. The anthropogenic factors that drives to the soil erosion, release of carbon to the atmosphere, and losing water storage capacity, are the abusive use associated lack of management in the tracks, fire by the vegetation damage.

Remote Sense and GIS are indispensable tools for environmental monitoring, evaluation and control.

Keywords: Water management; Soil Conservation; Natural Area Preservation.

Acknowledgements

TEMPUS FOUNDATION, CAPES, Szent István University, Federal Rural University of Rio de Janeiro, and the Itatiaia National.

References

Aximoff, I. A., Alves, R. G., & Rodrigues, R. de C. (2014). Campos de Altitude do Itatiaia: Aspectos Ambientais, Biológico e Ecológicos. Boletim Do Parque Nacional Do Itatiaia N. 18, 74.

Aximoff, I., & Rodrigues, R. de C. (2011). Histórico dos incêndios florestais no Parque nacional do Itatiaia. *Ciencia Florestal*, *21*(1), 83–92. https://doi.org/10.5902/19805098

Barreto, C. G., Campos, J. B., Roberto, D. M., Roberto, D. M., Schwarzstein, N. T., Alves, G. S. G., & Coelho, W. (2013). Plano de Manejo: Parque Nacional do Itatiaia - Encarte 3. Relatório Técnico Instituto Chico Mendes, 215.

Brazilian Institute of Geography and Statistics (IBGE), https://ww2.ibge.gov.br/english/ Accessed, March 2018.

Centers for Disease Control and Prevention 1600 Clifton Road Atlanta, GA 30329-4027, USA.

Köppen W. Climatologia: con un estudio de los climas de la tierra. México: Fondo de Cultura Econômica; 1948.

Lal, R. (2016). Soil health and carbon management. *Food and Energy Security*, (1), 1–11. https://doi.org/10.1002/fes3.96

Natural Earth, Free vector and raster map data at 1:10m, 1:50m, and 1:110m scales, http://www.naturalearthdata.com/. Accessed, March 2018.

QGIS Development Team, 2009. QGIS Geographic Information System. Open Source Geospatial Foundation. URL http://qgis.osgeo.org

United States Geological Survey, https://earthexplorer.usgs.gov/. Accessed, March 2018.

ANALYZING THE VERTICAL DISTRIBUTION OF FRESHWATER ALGAE IN LAKES

JánosGRÓSZ[1]—IstvánWALTNER[2] —ZoltánVEKERDY[3]

1 Szent István University, Páter Károly u. 1., 2100 Gödöllő, Hungary, grosz.janos.1@hallgato.szie.hu
2 Szent István University, Páter Károly u. 1., 2100 Gödöllő, Hungary, waltner.istvan@mkk.szie.hu; 3
University of Twente, Drienerlolaan 5, 7500 AE, Enschede, theNetherlands, z.vekerdy@utwente.nl

Abstract

Biological water quality analysis is a very significant part of water quality analysis. One of the most important biological parameter is chlorophyll-a content. In the aquatic ecosystem, there are many factors that can influence the vertical distribution of algae. These factors can be transparency, pH, nutrient enrichment, prey-predator relationship, fish population, structure of the lake, seasonal variations of sunshine, wind, water temperature, UV radiation, and underwater light condition. Spatial distribution of phytoplankton is very inhomogeneous in lakes. The appointed study area is Lake Naplás and it is located in Hungary. The purpose of our study was to collect data about the vertical distribution of phytoplankton together with the most important parameters. During the study, the main measured influencing factors were the accessible underwater light source, ultra-violet (UV) radiation and the water temperature. The results are built upon a complex and long-term in situ sampling and measurement series. During the study, 30 campaigns were carried out and more than 1000 samples were collected. According to the results, the vertical distribution of freshwater algae can be very diversified and it can depend on usable light source, part of the day and water tempera- ture.

Acknowledgments

This publication is created in number EFOP-3.6.1-16-2016-00016 The specialise of the SZIU Campus of Szarvas research and training profile with intelligent specialization in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production

EFFECTS OF WATER QUALITY ON THE MILLING CHARACTERISTICS OF AEROBIC RICE

IBADZADE Marks[1,2] *– SZÉKELY Árpád*[2] *– PENKSZA Károly*[1] *– JANCSÓ Mihály*[2]

1Szent István University, Faculty of Agricultural and Environmental Sciences,
2100 Gödöllő, PáterKárolyutca1., e-mail: marks.ibadzade@gmail.com
2NAIK Research Department of Irrigation and Water Management,
5540 Szarvas, Anna-liget8., e-mail: jancso.mihaly@ovki.naik.hu

Introduction

Rice (*Oryzasativa*L.) is a plant that requires permanent water supply and has a very low productivity in limited water resources. Moreover, rice plays an important role in the diet of the world's inhabitants which by far is the biggest user of irrigation water (Bouman et al. 2007,Wuthi-Arporn, 2009). However, during the lack of water, there are certain difficulties in growing rice.Breeding for drought tolerance of rice under the temperate climate is a complex challenge, because plants are usually exposed to multiple stressors (drought, salinity, low temperature, mechanical damage, etc.) (Courtois et al. 2012). Photoperiodic sensitivity, long duration and cold sensitivity limit the direct adaptation of tropical and subtropical aerobic rice varieties (Jancsó et al. 2017).

Under the stress, plant either stays out of growth or completely dies. In other words, the plant yields a weak crop (Yang 2012). In many countries or specific areas, there is a need for alternative sources of irrigation for rice production.On the other hand, the quality of the crop is also decreasing when stress occur.Aerobic rice is one of the rice growing technologies where drought stress can decline yield and quality if sufficient water supply is not maintained properly (Bouman et al. 2007).

Alternative water sources are more and more important for agricultural production. Effluent water from intensive technologies can be reused as irrigation water if the quality meets the requirements (Kun et al. 2017).

Post harvest operations are also important factors for quality. It is known that one of the parameters that determines the quality of rice is moisture content (Bell et al. 2000).

In our pilot experiment, basic quality parameters (moisture content, 1000 kernel weight (TKW) and milling degree) of a Hungarian rice variety grown in conventional and aerobic conditions were determined.

Material and methods

The experiment was conducted at the National Agricultural Research and Innovation Centre, Research Department of Irrigation and Water Management (NAIK ÖVKI) Galambos Rice Research Station (GRRS) and at the NAIK ÖVKILysimeter Station in Szarvas, Hungary (2017-2018). A Hungarian rice variety called M488 was chosen as model plant based on our previous results (Székelyet al. 2016), which was planted in 2017 into conventional and aerobic (lysimeter) conditions. In the lysimeter experiment, four types of irrigation water were used: (1) effluent water from an intensive fish farm, (2) effluent water supplemented with gypsum, (3) surface water from Körösriver, (4) effluent water mixed with surface water and supplemented with gypsum.In our case the source of effluent water was an intensive catfish farm located near to the experimental sites. The effluent water is characterized bya high sodium content (Kun et al. 2017). At the GRRS, with the conventional method of irrigation, the water of the Körös River was used for flooding.After harvest- ing and standard post-harvest operation (cleaning, drying, storing), the moisture content, 1000 Ker- nel weight (TKW) and a basic milling quality parameters (milling degree, polished rice) of each sample were analyzed. In order to determine moisture content of grains, Sartorius MA45 moisture analyzer was used. For obtain precise results in Kernel weight, we used a Sartorius BP221S analyti- cal balance.Experiments with the parameters of milling were carried out using standard laboratory equipments for rice quality analysis (Satake THU Laboratory Husker,Satake TM05 Test Mill).

Basic mathematical analyses were calculated using of Microsoft Excel.Data were statistically analysed (ANOVA) by IBM SPSS 22 software. Tukey-method was used to test differences among treatment means at 5% level of probability.

Results and discussion

It is known that one of the parameters that determines the quality of rice is moisture content (Bell et al. 2000). The moisture content directly affects the shelf life of any type of seed (Hanson 1985).Usually seeds' moisture content less than 14% is more desirable for storage purposes (Asea et al. 2010).It is also known that the ability to increase the development of insects is restricted in condition less than 12% moisture content (Befikadu 2014).In accordance with the initial stage of our experiment, each sample was specially distributed and prepared for testing.First, a sample of paddy rice was cut into small pieces (cca. 3g) and moisture content was measured. This test was repeated four times for each sample and the average moisture content (%) was calculated (Table 1).

Treatment (1)	**Moisture (2)**
	%
Effluent (45 mm/week)	8.39
Effluent+gypsum (45 mm/week)	8.11
Körös river (45 mm/week)	7.50
River+effluent+gypsum (45 mm/week)	6.98
Conventional, flood irrigation (anaerobic)	5.72

1. táblázat. A malomipari minőség meghatározásához használt rizsminták nedvességtartalma (Szarvas, 2018)
(1) öntözési kezelés, (2) magminta nedvességtartalma (%)
Table 1. The moisture content (%) of paddy seeds used for the quality tests (Szarvas, 2018).

The TKW shows the development of seeds, the amount of substance contained in the grain and its size(Alberta Agriculture and Food2007).It is obvious that the larger grain has a higher TKW too.To determine TKW, 100 seeds of rice which were taken from each treatment were counted and weighted in 4 repetitions. Later, paddy rice samples were hulled (cargo rice) and again weighted.However, the results obtained after the measurements were multiplied by 10 to calculate TKW (Table 2).

Treatment (1)		**TKW of paddy seed (2)**	**TKW of cargo seed (3)**
		(g)	**(g)**
Effluent (45 mm/week) (lysimeter experiment)	Average	25.323 a	17.272 c
	SD	2.164	0.827
Effluent+gypsum (45 mm/week) (lysimeter experiment)	Average	22.936 b	18.100bc
	SD	0.184	0.487
Körös river (45 mm/week) (lysimeter experiment)	Average	23.975ab	18.629 b
	SD	0.256	0.269
River+effluent+gypsum (45 mm/week) (lysimeter experiment)	Average	23.901ab	18.769 b
	SD	0.416	0.485
Conventional, flood irrigation (anaerobic)	Average	25.758a	20.612 a
	SD	0.392	0.213

2. táblázat Különböző termesztési rendszerben, különböző minőségű öntözővízzel nevelt rizs növények ezerszem tömeg (EMT) értékei (Szarvas, 2017)
(1) öntözési kezelés, (2) pelyvás rizs EMT, (3) cargo (barna) rizs EMT, (ab) statisztikailag igazolható különbség
Table 2. Thousand kernel weight of paddy and cargo seeds of rice developed with different quality of irrigation, (ab) significant difference(Szarvas, 2017).

The results show that TKW of paddy rice was influenced by quality of irrigation water and growing conditions. TKW was significantly higher when we used conventional flooding or sole effluent water compared to the treatment of effluent water supplemented with gypsum. In case of cargo seeds, conventional flooding gave the best result of TKW. The higher TKW can be a result of better conditions in case of flooding (higher biomass) and a result of stress conditions in case of effluent treatment (less seeds in panicles).

The basic reason of milling is to achieve polished (white) rice by removing husk and bran layer of paddy seeds (IRRI 2018). In our milling test, 100 g of each sample was selected. First, hull was removed and seeds were analysed, then they were further polished.At the end of the process, samples were weighted and different seeds (whole, broken) were separated. The results of milling test are shown in the Table 3. Significant differences were observed when we analysed the effects of irrigation sources for the basic milling parameters of the selected Hungarian rice variety.

Conclusions

Various irrigation waters ((1) effluent water from an intensive fish farm, (2) effluent water supplemented with gypsum, (3) surface water from Körösriver, (4) effluent water mixed with surface water and supplemented with gypsum) were used to study the effect of irrigation on rice. During experiment moisture content of seeds in all treatment were less than the standard 14%. Significant differences were found when we calculated TKW. TKW was significantly higher when we used conventional flooding or sole effluent water compared to the treatment of effluent water supplemented with gypsum.In the milling test,significant differences were observed when we analysed the effects of irrigation sources for the selected Hungarian rice variety.In case of traditional flooding, significantly higher amount of broken polished grains was measured. But generally, we can say these treatments were allfavourable for basic quality parameters of rice.

Treatment (1)		**Cargo (2)**	**Polished (3)**	**Polished (whole) (4)**	**Polished (broken) (5)**
		(%)	**(%)**	**(%)**	**(%)**
Effluent (45 mm/week) (lysimeter experiment)	Average	80.4	70.0	57.7 b	11.3 c
	SD	0.316	0.374	1.744	0.878
Effluent+gypsum (45 mm/week) (lysimeter experiment)	Average	80.2	70.7	62.0 a	7.9 b
	SD	0.096	0.661	0.970	0.500
Körös river (45 mm/week) (lysimeter experiment)	Average	80.0	68.2	61.6 ab	7.6 b
	SD	0.173	0.665	1.462	1.055
River+effluent+gypsum (45 mm/week) (lysimeter experiment)	Average	79.9	70.0	63.8 a	5.9 a
	SD	0.096	0.420	0.975	0.877
Flood irrigation	Average	79.7	69.4	52.2 c	17.3 d
	SD	0.163	2.649	3.091	0.793

3. *táblázat* Különböző termesztési rendszerben, különböző minőségű öntözővízzel nevelt rizs malomipari kihozatala (Szarvas, 2017)
(1) öntözési kezelés, (2) cargo kihozatal (%), (3) csiszolt kihozatal (összes, %), (4) csiszolt kihozatal (egész, %), (5) csiszolt kihozatal (tört, %)
Table 3. Milling quality parameters of cargo and polished seeds of rice developed with different quality of irrigation, (ab) significant difference (Szarvas, 2017).

Summary

Rice is a plant that requires permanent water supply and has a very low productivity in limited water resources. One of the main factors which define rice quality is water. In order to better understand the effect of water quality on rice, we used 4 types of irrigation water (effluent water from an inten- sive fish farm, effluent water supplemented with gypsum, surface water from Körösriver, effluent water mixed with surface water and supplemented with gypsum) during the experiments under aerobic and flooded conditions.

Usually, when plants suffer from stress, several changes appearin seeds.Therefore, sufficient water must be providedto plantsduring the growing season.Quality parameters (moisture content, TKW and milling degree) of rice seeds were determined. Although some indicators show significant differences (TKW, whole polished grains, broken grains)under different irrigation qualities, with all the water types the plants were able to reach a favourable milling quality.

Keywords:aerobic rice, irrigation quality, grain quality test

Acknowledgement

The Authors thank for the great assistance to Tímea Szalóki, MáriaSzedljakné, Márta Lustyikné, Imre Babák and all of the technical staff at NAIK ÖVKI. The experiments were supported by the Hungarian Ministry of Agriculture under the Project for Development of Irrigation Management (FM O15500, FM O15540). Ibadzade Marks is a scholarship holder of StipendiumHungaricum.

References

Alberta Agriculture and Food:2007. Using 1000 Kernel Weight for Calculating Seeding Rates and Harvest Losses.Agri-Facts, Agdex 100/22-1, 5 p.

Asea G. – Onaga G. – Phiri V.A. – Karanja D.K..: 2010. Quality Rice Seed - Production Manual.National Crops Resources Research Institute, CABI Africa, pp. 65-66.

Befikadu D.: 2014. Factors affecting quality of grain stored in Ethiopian traditional storage structures and opportunities for improvement.International Journal of Sciences:Basic and Applied Research, 18(1): 235-257.

Bell M.A. – BakkerR.R. – de Padua D.B. – RickmanJ.: 2000. Rice quality management - principles and some lessons. In: Johnson G.I., Le Van To, Nguyen Duy Doc, Webb M.C. (eds.) ACIAR Proceedings 100, 110 p.

Bouman B. A. M. – Lampayan R. M. – Tuong T. P.: 2007. Water management in irrigated rice: coping with water scarcity. International Rice Research Institute, Los Baños (Philippines) 54 p.

Courtois B. – Frouin J. – Greco R. – Bruschi G. – Droc G. – Hamelin C. – Ruiz M. – Clément G. – Evrard J. – Coppenole S. – Katsantonis D. – Oliveira M. – Negrão S. – Matos C. – Cavigiolo S. – Lupotto E. – Piffanelli P.– Ahmadi N.: 2012.Genetic Diversity and Population Structure in a European Collection of Rice. Crop Sci. 52: 1663–1675.

Hanson J.: 1985. Procedures for handling seeds in genebanks.IBPGR, Rome 115 p.

IRRI: 2018.Rice Milling – Teaching Manual(http://www.knowledgebank.irri.org), International Rice Research Institute, The Philippines, 11 p.

Jancsó M. – Székely Á. – Szalóki T. – Lantos Cs. – Pauk J.: 2017.Performance of rice varieties under aerobic conditions in Hungary.Columella.4: 1.83-88.

Kun Á. – Bozán Cs. – Barta K. – Oncsik M.B.: 2017. The effects of wastewater irrigation on the yield of energy willow andsoil sodicity.Columella, 4(1): 11-14.

Székely Á. – Szalóki T. – Jancsó M.: 2016. A sóstressz hatásai a rizs korai fejlődésére (inHungarian). In: Futó Zoltán (szerk.) Kihívások a mai modern mezőgazdaságban. Szent István Egyetemi Kiadó, pp. 91-96.

YangC.: 2012.Technologies to improve water management for rice cultivation to cope with climate change. Crop, Environment &Bioinformatics, 9: 193-207.

Wuthi-Arporn J.: 2009. Increasing rice production: Solution to the global food crisis.International Students Summit, Tokyo University of Agriculture Press, Tokyo, (http://www.nodai.ac.jp/) p. 9.

A vízminőség hatása az aerob rizs malomipari tulajdonságaira

Összefoglalás

A rizs (*Oryzasativa* L.) fejlődése során folyamatos és kiegyensúlyozott vízellátást igényel, vízhiányos környezetben a produktivitás jelentősen csökken. A termény fontos minőségi jellemzője a malomipari felhasználhatóság, amelyet nemcsak az öntözővíz mennyisége, hanem a minősége is döntően befolyásol. Azért hogy jobban megismerhessük a víz összetételének hatását a fejlődő rizsszemekre, négy különböző öntözővízzel (intenzív halnevelő telep elfolyó vize, elfolyó víz és gipsz kiegészítés, folyóvíz, folyóvíz, elfolyó víz és gipsz kiegészítés) öntöztük a parcellákat aerob körülmények között. Kontrollként a hagyományos, árasztott termesztésből származó növények termését használtuk. A betakarítás után meghatároztuk a legfontosabb malomipari minőséget jellemző paramétereket (EMT, hántolási kihozatal, szemforma). Az eltérő kezelések ellenére a minőség paraméterek között csak az EMT értékekben és a csiszolt egész/tört szem arányban találtunk szignifikáns eltéréseket.

Kulcsszavak: aerob rizs, öntözővíz minőség, malomipari minőség

PHILIPPINE WATER RESOURCES

Jovito L. Opena

Szent István University

Abstract:

This paper presents a synthesis of the realities facing the water resources in the Philippines. It discusses the country's current water condition and the threats that limit its continuous supply in the future. Among the threats cited in this paper were urbanization and industrialization, pollution, watershed degradation, climate change, and institutional weaknesses. The paper also presents the challenges like equitability in the access to water resources and sustainability of this very important resource.

WATER MANAGEMENT PROPERTIES OF ROOT MEDIA USED IN SOILLESS CULTIVATION

Noémi Kappel

1 Szent István University, Faculty of Horticultural Science, Department of Vegetable and Mushroom Growing, 1118-Budapest Villányi str. 29-43. e-mail: kappel.noemi@kert.szie.hu

Introduction

A substrate growing system is a hydroponic version where the root zone is physically supported by media. The primary reason for using any substrate, in a hydroponic growing system is to provide a buffering reservoir of nutrient solution in the root zone while maintaining an adequate volume of air (oxygen) in contact with the roots. The quality of the root medium is one of the most important issues in media based soilless cultivation, too. Irrigation management in hydroponics therefore is more sensitive than in soil-based systems.As to the determination of the physical properties of the media, there is no unanimous consensus on the characteristics to be measured and the methods to be applied. Among the characteristics bulk density, pore space, air and water capacity and particle size distribution are indicators which determine the physical properties of a material.

Literature review

Almost any material that supports the root system, other than soil, is considered a sub-strate(Biernbaum, 1992). Substrates can be organic (peat, coconut coir)or inorganic minareal based (rockwool, perlite) commonly used in practice. Peat has long been used as basic organic material for potting soils both for vegetables and ornamentals in media based soilless cultivation. Besides the use of peat base mixtures the use of peat substitutes is becoming more and more common. Coconut (*Cocus nucifera* L.) coir, which is the mesocarp of the fruit, could become a very suitable peat sub- stitute thank to its chemical and physical properties very similar to those of peat (Bragg et al.,1993*;* Savithri and Hameed, 1994).Organic substrates have excellent water holding and release charac- teristics but they decompose over a period of time. As decomposition proceeds the water holding capacity of the substrate changes. Organic substrates, especially peat, have some cation exchange capacity. This gives the grower some buffer against nutrient changes in the root zone.

Rockwool and perlite are the most widespread used inorganic substrates in media based hydroponic production.The main features are that they have little cation exchange capacity and they maintain their structure over a long period of time. In general, at field capacity, rockwool holds more water per unit volume than the other inorganic substrates and therefore has a greater buffering capacity. The larger reserves of a nutrient solution coupled with excellent drainage makes rockwool easier to handle as an inorganic substrate.

In a growing media water often appears as a non-limiting factor because it can be applied at any frequency in accordance with the growing requirements. Instead, the question of aeration is consid-ered as a matter of primary importance.

In the investigation of substrates many paper reported (Martinez et al,1997*;* Prasad,1997*;* Wever and Leeuwen,1994), that coconut coir and peat have the same bulk density, on the other hand coco- nut coir has a higher total pore space and water capacity. Peat, coconut coir and vermiculite have a higher water capacity than perlite(Bunt, 1983). Verdonck et al.(1983), after having tested several materials, concluded that the materials used for making artificial soil mixtures have different physi- cal characteristics, in particular, have different contents of air and readily available water. The ques- tion whether the water held in a medium is available or unavailable depends on how far the roots are situated from the water and at which force it is adsorbed to the particles of the medium(Fonteno, 1989). The weight and volume of a given medium are influenced by water content, compaction level and particle size distribution (Wilson,1983). Waller and Wilson(1983) also highlight the im- portance of knowing composition, water and organic material content. Several researchers have demonstrated in their studies that total pore space of a root medium is inversely proportional to the bulk density (Beardsell et al., 1979; Hanan et al.,1981; Bunt, 1983).

Material and methods

Investigation of growing media:

Mainly focusing on the organic based growing substrates during previous works some Hungarian lowmoor peat and some Sphagnum highmoor peat samples were collected, as well as coconut fiber and from the inorganic group the perlite physical properties were tested in laboratory.

In determining the major physical parameters, sampling and sample preparation have an influence on measurement results. Since the bulk density of the media may vary considerably, I used heat resistant plastic tubes of 100 cm^3 for the analysis of the samples and the uniform filling of the cylin- ders was performed by the help of a special volume measuring device.

Out of the physical parameters the following ones were determined:

- texture (particle size distribution) [%],
- hygroscopic property,
- capillary rise [mm],
- determination of water capacity (capillary, maximum and minimum) [weight% and volume%]
- bulk density [g/cm3],
- density [g/cm3],
- total porosity [V%],
- determination of capillary and non-capillary pores [V%],
- porosity conditions (differentiated porosity, qualitative distribution of pore space) [%],
- determination of moisture content [%].

Results and evaluation

In table 1. I summerized just the most important results of the tested substrate's physical parameters. In terms of the dry bulk densities (g/cm^3) of the media, according to my measurements, lowmoor peats have obviously greater bulk densities (0.22-0.26 g/cm^3) than fibrous *Sphagnum* peats (0.08-0.1 g/cm^3). Coconut coir had a density (0.08 g/cm3) similar to that of highmoor peat and perlite.

When characterizing the pore space of the media I came to a conclusion similar to that of other researchers, i.e. that the higher the bulk density the lower the total pore space.Peats were characterized by high total porosity and this value was always over 80%. The ample macropore space is important in allowing faster water movement. Perlite had a total porosity very similar to coconut coir, and to the *Sphagnum* peat, had a total porosity of 94%.

According to literature data the optimal condition for root growth is when the capillary and non capillary pores ratio is 50:50 %. I observed different distributions for the constituents of my media. The values that I obtained for the size of capillary pore space were as follows: *Sphagnum* peat 30-34%, perlite close to 40%, coconut coir 75% and decomposed black peat 73-75%. Sothe fibrous *Sphagnum* peats have less capillary pore space and therefore a poorer water storage capacity, as compared to decomposed black peats. Coconut coir is characterized by a bulk density and total porosity that are identical to fibrous *Sphagnum* peat, but its water retention capacity is much better. The pore space of the perlite is dominated by non capillary pores which are responsible for aeration.

In the medium in contact with a free water surface water will rise in the pores. This characteristic is connected with the particle composition. The height of capillary rise is inversely proportional to the diameter of the pores involved in water rise. The poorest water rise was seen with the dry *Sphagnum* peat, hardly reaching 50 mm in 48 hours. Coconut coir had the statistically significantly best water rise.

	Bulk density (g/cm^3)	Total pore space (%)	Capillary pores (%)	Non capillary pores (%)	Capillary rise 1 hour (mm)	Capillary rise 48 hours (mm)
Lowmoor peat	0,22-0,26	89,7	73-75	21,0	29,5	119,5
Highmoor peat	0,08-0,1	94,5	30-34	65,6	4,0	52,5
Coconut fiber	0,08	90,3	75	23,0	141	295
Perlite	0,09	94,5	37,6	56,8	18	133

Table 1. The most important physical parameters of the tested subtrates

Conclusions

In the laboratory, root-medium physical properties are influenced by bulk density (Bunt, 1983; Beardsell et. al., 1979; Hanan et al.,1981), particle size (Bunt, 1983) and container height (Fonteno and Nelson, 1990; Milks et al., 1989). In the greenhouse, physicalproperties also are influenced by irrigation method, applied watervolume, and media moisture content (Argo and Biernbaum, 1994; Beardsell and Nichols, 1979; Bunt, 1983). Understanding the root environment under production conditionsrequires an understanding of the dynamic nature of air : water ratio inthe medium and the limitations of static laboratory physical propertymeasurements.

The physical properties of the subtstrates have a great influence on plant development. The national literature is very scarce in methods for the determination of the physical properties. The measuring methods elaborated in detail for mineral soils are not fully adaptable to substrates. The greatest problem consists in sampling. The most crucial parameters (bulk density, porosity conditions and water capacity) are dependent on the size and compaction of the sample.

Summary

The knowledge of the most important physical characteristics of the root media (bulk density and particle size, water capacity, pore space conditions) can be a great help to understand the effect of the substrates on the plant development.

Substrates are very difficult to study in this aspect, partly because of the scarcity of the national literature and partly because of the lack of exact analytical methods. The measurement methods elaborated for mineral soils cannot be mechanically adapted to the investigation of such media. In determining the physical characteristics it is necessary to have regard to the fact that plants are grown in the media at higher moisture contents.

The water regime of a root medium can be characterized by aeration, readily available water content and water storage capacity. The proportion of capillary and non capillary pores in total porosity is also an indication of growing media characteristics.

Keywords: substrates, physical properties, pore space, capillarity

Acknowledgement

This publication is created in number EFOP-3.6.1-16-2016-00016 The specialise of the SZIE Campus of Szarvas research and training profile with intelligent specialization in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production

References

Argo, W.R. - J.A. Biernbaum.: 1994: A method for quantifying plant available water holding capacity and water absorption potential in container media under production conditions. HortScience 29(5): 501. (Abstr.)

Beardsell, D.V. - D.G. Nichols - D.L. Jones: 1979: Physical properties of nursery potting materials. Scienta Hort. 11: 1-8.

Biernbaum, J.A. 1992: Root zone management of greenhouse container-grown crops to control water and fertilizer use. HortTecnology 2(1):127-132.

Bragg, N.C. - J.A.R. Walker - E. Stentiford - M. Tantini.:1993: The use of composted refuse and sewage as medium additives for container grown plants. Acta Hort. 401: 155-165.

Bunt, A.C.: 1983: Physical properties on mixtures of peats and minerals of different particle size and bulk density for potting substrates. Acta Hort. 150: 143-153.

Fonteno, W.C.: 1989: An approach to modelling air and water status of horticultural substrates. Acta Hort. 238: 67-74.

Fonteno, W.C. - P.V. Nelson.: 1990: Physical properties of and plant responses to rockwool-amended media. J. Amer. Soc. Hort. Sci. 115(3): 375-381.

Hanan, J.J. - C. Olympos - C. Pittas: 1981: Bulk density, porosity, percolation and salinity control in shallow, freely draining, potting soils. J. Amer. Soc. Hort. Sci. 106 (6): 742-746.

Martinez, F.X., - N. Sepo - J. Valero: 1997: Physical and physicochemical properties of peat-choir mixes and the effects of clay-material addition. Acta Hort. 450:31-46.

Milks, R.R. - W.C. Fonteno - R.A. Larson.: 1989: Hydrology of horticultural substrates: II. Predicting physical properties of substrate in containers. J. Amer. Soc. Hort. Sci. 114: 53-56.

Prasad, M.: 1997: Physical, chemical and microbiological properties of coir (cocopeat). Acta Hort. 450: 21-27.

Savithri, P. - K.H. Hameed: 1994: Characteristics of coconut coir peat and its utilization in agriculture. J. Plant Crops 21: 1-18.

Verdonck, O. -R. Penninck - M. De Boodt: 1983: The physical properties of different horticultural substrates. Acta Hort. 150: 155-160.

Waller, P.L. - F.N. Wilson: 1983: Evaluation of growing media for consumer use. Acta Hort. 150: 51-57.

Wever, G. - A.A. Van Leeuwen: 1994: Measuring mechanical properties of growing media and the influence of cucumber cultivation on these propeties. Acta Hort. 401: 27-34.

Wilson, G.C.S.: 1983: The physico-chemical and physical properties of horticultural substrates. Acta Hort. 150: 19-32.

DIGITALIZATION IN THE AGRICULTURAL mechanization

I. Kovács[1]; I. Husti[1], Z. Bártfai[2], Z. Blahunka[2]

1Institute of Engineering Management,
2 Institute of Mechanics and Machinery
SzentIstván University
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+3628 522-000, E-mail: kovacs.imre@gek.szie.hu

Introduction

Hungary is famous for its agricultural production. Compering with the best agricultural producers, on the field of corn, sunflower, wheat, pork, fruit, milk production our achievement is considerable. Agriculture, rural area and farmers are of particular importance when it comes to digitalism modernization reform. The intensity of the economic development of our country is very much depend on the successful application of the spreading IT technologies in the agricultural production. Precision farm technologies, application of robots on field will determine our technical development within the next few years.

From Industry 4.0 to Agricultural 4.0

According to some definitions, Industry 4.0 is a frame of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of Things and cloud computing.Industry 4.0 includes all those innovative solution, methods that can compose an intelligent production system called „Smart Factory". Within the modular structured smart factories, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the IoT, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services. Both internal and cross-organizational services offered and used by participants of the value chain. Cloud computing is already a well-known IT technology.It has the following five features: on-demand service, internet access, resource polling, rapid elasticity and calculability. In this way some sensors –controlling the process- connect to the internet ensuring the adequate information. The so called "Smart Agriculture" based on Cloud Computing, and IoT realize concentrated management and control of machine, equipment and personnel, based on the internet and improve production through more detailed and dynamic means. This is useful for effective integration between human society and the physical world, and regards as the third wave of information industry development following computerisa- tion and internet. IoT technologies include RFID, sensor network technology, and internetwork communication, all of which have been involved in the four links of IoT industrial chain, namely: identification, sensing, processing and information delivery. *(TongKe, 2017)*

Agriculture 4.0 -analogy to Industry 4.0- stands for the integrated internal and external networking of farm operations. Information in digital form exists for all farm sectors and processes; communi- cation with external partners - suppliers and end customers- isperformed electronically; and data transmission, processing and analysis are largely automated. The use of Internet-based portals can facilitate the handling of large volumes of data, as well as networking within the farm and with external partners*(CEMA/b, 2017).*

Other terms frequently used are "Smart Agriculture" and "Digital Farming". It is based on the emergence of smart technology in agriculture. Smart devices consist of sensors, actuators and communication technology.

The main stations of agriculture development

Agriculture 1.0

Situation in the early 20th century. A labour-intensive system of agriculture with low productivity. It was able to feed the population but required a vast number of small farms and a third of the population to be active in the primary agricultural production process.

Agriculture 2.0

This phase of farming began in the late 1950s when agronomic management practices like supplemental nitrogen and new tools like synthetic pesticides, fertilizers and more efficient specialized machines allowed to take advantage of relatively cheap inputs, thus dramatically increasing yield potential and growing returns to scale at all levels.

Agriculture 3.0

"Precision Farming" started once military GPS-signals were made available for public use.Precision Farming entails solutions for:

- **Guidance**: early adopters in the mid-1990s were using GPS-signals for manual guidance. They built further on technology used in aerial spraying. The first automatic steering solutions appeared in the late 90s. During the 2000s, guidance accuracy was improved to 5 cm.
- **Sensing & control**: during the 1990s, combine harvesters were equipped with yield monitors based on GPS location. The first automatic Variable Rate Application (VRA) started at the same time. Low fertiliser prices and high technology costs initially limited adoption of variablerate technology. In the early days, VRA was based on soil sampling input, but performance improved drastically based on data gathered by yield monitors.
- **Telematics**: Telematics is a technology used to monitor vehicle fleets. It appeared in the early 2000s, and was inspired by the transportation industry. It is based on cellular technology and allows the optimisation of the logistics processes on the farm. (**Fig. 1**)
- **Data Management**: Farming software has become widely available since the birth of the PC in the early 80s.

Agriculture 3.0 can be seen as the gradual introduction of more and more advanced and mature Precision Farming technologies. The focus is moved from pure efficiency in terms of cutting costs to profitability which can be seen as objectively and creatively seeking ways to lower costs and enhance quality or develop differentiated products.

Agriculture 4.0

A new boost in precision agriculture can be observed around the early 2010s based on the evolution of several technologies:

- Cheap and improved sensors and actuators
- Low cost micro-processors
- High bandwidth cellular communication
- Cloud based ICT systems
- Big Data analytics

As of the 2010s, smart technologies are also increasingly fitted as standard features on tractors, combine harvesters and other equipment, like:

- Smart control devices (on-board computers)
- Many sensors for the operation of the machine and the agronomic process
- Advanced automation capabilities (guidance, seed placement, spraying, etc)
- Communication technology (telematics) embedded in the vehicle. *(CEMA/b, 2017)*

This evolution happens in parallel with similar evolutions in the industrial world, where it is marked as "Industry 4.0", based on a vision for future manufacturing. Accordingly, the term "Agriculture 4.0" is often used in farming. Agriculture 4.0 paves the way for the next evolution of farming consisting of unmanned operations (for example BoniRob) and autonomous decision systems. Agri- culture 5.0 will be based around robotics and (some form of) artificial intelligence. *(Harold, 2016)*

Digital agriculture offers new opportunities through the ubiquitous availability of highly interconnected and data intensive computational technologies as part of the so-called Industry 4.0.In the concept of the digital agriculture the determining conglomerations develop their own IT technology based production system. Fuse is AGCO's approach to precision agriculture, delivered through technology products and services. This approach ensures growers' operations are always running and optimized, all assets are in the right place at the right time and each phase of the crop cycle is seamlessly connected through total farm data management. Fuse enables more informed business decisions, reduced input costs and improved yields and profitability. Fuse Technologies is the technology foundation of the optimized farm. Tools including guidance, telematics and advanced sensors create smart, connected machines, fine-tuned for each application, that can communicate with farm managers, 3rd party service providers and each other.Fuse Connected Services combines the right machines, technology, parts, service and support for customers. This complete solution optimizes the customer's operation and maximizes uptime through preventative maintenance, machine condition monitoring and year-round consultation.

Fig 1. Precision farming (AGCO FUSE technology)
(https://www.agcotechnologies.com/about-fuse/)

Digital Agriculture can leverage the smart use of data and communication to achieve system optimization. The tools that enable digital agriculture are multiple and varied, and include cross-cutting technologies such as computational decision and analytics tools, the cloud, sensors, robots, and digital communication tools. In addition, field-based activities are enabled by geo-locationing tech- nologies such as Global Positioning Systems (GPS), geographical information systems, yield moni- tors, precision soil sampling, proximal and remote spectroscopic sensing, unmanned aerial vehicles, auto-steered and guided equipment and variable rate technologies. Animal housbandry technologies include radio frequency identification (RFID chips), automated (robotic) milking, and feeding systems, among others. Controlled-environment agriculture (greenhouses, indoor farms, etc.) enabled also increasingly by digital technologies, such as sensors and robots. Digital agriculture can potentially accumulate large amounts of data, and analytical capabilities that facilitate the effective employment of these data are key implementation factors.

CASE STUDIES FOR DIGITALISATION IN AGRICULTURAL MECHANISATION AND MACHINERY

1) The tools of geo-locationing by John Deere

The StarFire 3000 receiver (**Fig 2.**) picks up satellite signals from the Global Positioning System GPS and has the capability to use GLONASS satellites (Russian navigation satellite system, similar to GPS) to maintain guidance performance even in shaded conditions and other unpredictable environments. Moreover, the receiver is designed to utilize satellites as low as 5 degrees above the horizon. Due to the improved satellite availability, the StarFire 3000 provides a more reliable position. John Deere terrain compensation technology with the StarFire 3000 receiver provides the capability to detect the roll, pitch, and yaw of the vehicle. So the receiver can compensate accordingly to ensure true vehicle position with respect to the ground throughout the field. *(John Deere, 2017)*

Fig 2. An John Deere 6150R with the StarFire 3000 Receiver
(Photo: I. Kovács, 2016)

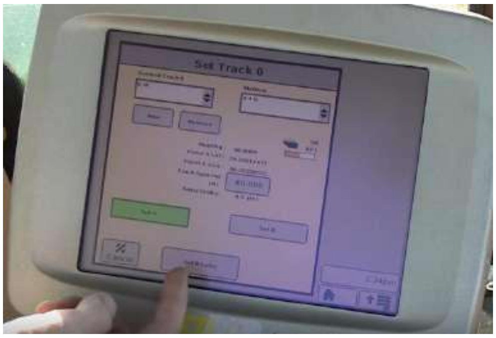


Fig 3. Set the A-B line for the AutoTrack on the GreenStar 3 2630 Display
(Photo: I. Kovács, 2016)

A variety of John Deere precision applications can run on the GreenStar 3 2630 Display (**Fig. 3**) with a StarFire 3000 receiver regardless if it is planting or harvesting season, or for any application in between.

2) Applications of mobile robots on the field

According to the "forecast" it is time to deploy robots on farms, and there is a clear need to do so given the drive for increased food production, and sustainability. Steps are currently being made to develop the technology that will enable the automation of individual tasks before integration in a "digital farm" that will empower farmers to run operations in a fulfilling and efficient way. According to the request robots have to be "quick, precise, 100% successful, and cost-effective" before we can hope to see them on the modern farms. A trend towards human-robot co-working can also be seen. With one or more robots doing (part of) the job while being supervised, instructed by a human, or jointly working with a human. This might improve acceptance and feasibility of robotics technology for the more challenging tasks in agriculture.

Tomorrow's farm will include many robots working together. TheMARS project, which stands for Mobile Agricultural Robot Swarms, demonstrates a cloud-based approach to farming. By deploying many simpler and smaller robots, they hope to make their farm-solutions safer, more reliable, and productive, while avoiding soil compaction that comes with larger robots navigating the fields. A swarm could also provide continuous operation, by having robots take turns charging or undergoing maintenance

Fig. 4. MARS project conception
(http://robohub.org/farming-with-robots/)

At the Faculty of Mechanical Engineering in Gödöllő we work on a research project to elaborate a new method for monitor soil surface roughness using autonomous mobile robot. I this process the mobile robot having an IMU (Inertial Measurement Unit) cruises through an agricultural field. While it is cruising, the chassis rolls over the clods of earth. By measuring the rolls we are able to estimate the roughness of the field. Using some statistical methods we can deduct the numbers of clods. Finally we calculate the entropy of the surface.Processing IMU signals we are able to obtain terrain classifi- cation.

Fig. 5.Mobile robot moving on the field to mapping with laser scanner
(Photo: Z. Blahunka, 2015)

CONCLUSIONS

Agriculture has a long and proud past history in applying digital systems including farming operati- ons. Although there have been significant strides forward in improving the leading of farm mana- gers there are still areas for improvement.Agriculture differs from industry in several aspects but smart technologies can also be used in agricultural production. In the development of technical elements of crop productionthedevelopment ofdigital played a dominant role in thepast few years. The focus of the digital development of power and working machines was on the more preciselyde- termination ofthelocation of machine-relations. Thedataflow between datacollectorsensors and the central processing unit is regulated by international standards during theoperations. Alldata collec- tedduring the operations can evaluated by using the modular builtresourceplanning systems. GPS controlled agricultural robots work in plant production and in animal husbandry. Smart farming makes use of GPS services, machine to machine (M2M) and Internet of Things (IoT) technologies, sensors and big data to optimize crop yields and reduce waste. Company leaders and senior executi- ves need to understand their changing environment, challenge the assumptions of their operating teams, and relentlessly and continuously innovate.

REFERENCES

CEMA (2017)/a: Connected Agricultural Machines in Digital Farming. http://www.cema-agri.org/publication/connected-agricultural-machines-digital-farming

CEMA (2017)/b: Digital Farming: what does it really mean? Agricultural 4.0-hoz http://www.cema-agri.org/page/digital-farming-what-does-it-really-mean

F. TongKe (2017): Smart Agriculture Based on Cloud Computing and IOT. Modern Education TechnologyCenter of Xi'an International University, Shaanxi,710077 https://pdfs.sematicscholar.org/62ee/b701c40626811a1111ca5d1db37650f1ea0b.pdf

I. Husti; M. Daróczi, I. Kovács (2017): Messages from "Industry 4.0" to agriculture SzentIstván University, Engineering Management Institute, Gödöllő, Hungary, (under printing)

John Deere (2017): Agricultural Management Solutions (AMS) https://www.deere.co.uk/en/agricultural-management-solutions/receivers-displays/greenstar-3-display-2630/

Magó L.: (2002) „Economically Reasonable Using of Different Power Machines According to the Farm Sizes", Hungarian Agricultural Engineering, Periodical of the Committee of Agricultural Engineering of the Hungarian Academy of Sciences, Vol. 15/2002. p. 79-82.

S. Romeo (2016): Enabling Smart Farming through the Internet of Things Current Status and Trends. Principal Analyst – Beecham Research, Sensing Technologies for Effective Land Ma- nagement Workshop, Bangor University http://www.nrn-lcee.ac.uk/documents/5.SaverioRomeoSmartFarming.pdf

Z Bártfai, Z Blahunka, D Faust, P Ilosvai: Application of the combined wireless sensor network-, and mobile robot technology for monitoring, Mechanical Engineering Letters, SZIE GÉK, 2010

Z.Blahunka-Z.Bártfai-D.Faust : Measurement optimalisation by information entropy Mechanical Engineering Letters, 2015, Vol.13

http://robohub.org/farming-with-robots/

Acknowledgments

This publication is created in number EFOP-3.6.1-16-2016-00016 The specialise of the SZIU Campus of Szarvas research and training profile with intelligent specialization in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production

Abstract

Nowadays many experts consider the utilization of the digital technology as a determining factor of the agricultural production. The improvement of the agricultural mechanization and the effecti- veness of the machinery management highly depends on the application of the up-to-date info-communication technologies, M2M systems, wireless measuring technics, and field robotics.

Our article reviews the connection between Agricultural 4.0 and Industry 4.0., deals with some up-coming IT based technologies as Internet of Things (IoT), Cloud Computing, and Big Data analysis, not forgetting to focus on the agricultural utilisation of them where they appear as "Smart Farming".

Keywords: Industry 4.0, Agricultural 4.0, Precision agriculture, Smart Farming, Field robotics

CHARACTERIZATION OF MOBILITY OF POTENTIALLY TOXIC ELEMENTS IN SOIL-WATER SYSTEM BY SEQUENTIAL EXTRACTION PROCEDURES

KHUMALO Lamlile[1] – Dr. HORVATH Márk[1]– Prof. HELTAI György[1]*

1Szent Istvan University, Gödöllő, Páter Károly u. 1, 2100,*e-mail: lamlilekhumalo@gmail.com

Introduction

South Africa is located in the same type of subtropical high-pressure zone that renders much of Africa`s north of the equator a desert. However, South Africa is a generally water scarce country with many areas receiving much less rainfall than potentially lost to the atmosphere (Winde, 2011).In contrast to most other countries, South Africa's water supply systems currently rely mostly on surface water instead of groundwater, with large volumes of water stored in shallow dams(Winde & Stoch, 2010). Whilst the decreasing quantity of water has been a concern for decades, more re- cently these concerns have been compounded by water quality issues resulting from water pollution (Reid and Visser, 2013), including potentially toxic elements (PTEs) and radioactive nuclides pol- lution from gold mining activities.South Africa has been generally producing uranium as a by- product of gold mining since the gold rush in 1886 (The Atomic Energy Corporation of South Afri- ca Limited, 1988). South Africa has five gold mining basins, which collectively have resulted in the largest gold and uranium mining basin in the world. The smallest of the basins, the West Rand ba- sin, has fully flooded with acid mine water for over ten years. The acid water from this basin conta- ins uranium, manganese, aluminium, copper and other toxic and radioactive metals which flow into the river systems, the artificial reservoirs, into the soil and into the environment (Liefferink, 2014).

The Organisation for Economic Co-operation and Development (OECD) (1999) reported on the environmental activities in uranium mining and milling. In this report, an overview of environ- mental activities related to uranium production was presented. The report also reflected on the inc- reasing awareness in all countries of the need for environmental protection. According to OECD (1999), large programmes have been underway in several countries to clean up wastes from closed uranium mines and mills. The activities and concerns raised in this report were based on survey responses from 29 countries, including South Africa and Hungary.

Hungary is a lowland country, situated in the Carpathian Basin in the heart of Europe. Its terrain is relatively unvaried, 68 % of its area is below 200 m altitude, 30 % is covered by hills (200-400 m), and only 2 % exceeds 400 m. The highest peak of Hungary is the Kékes (1014 m). The entire area of the country (93000 km^2) belongs to the Danube catchment. The Danube catchment is the second largest in Europe, covering over 800000 km^2. The natural water balance of Hungary is positive, the total precipitation is 55707 million m^3, while the evapotranspiration is 48 174 million m^3(National Water Programme of the Hungarian Academy of Sciences, 2017). Uranium mining and processing had been part of Hungary since 1958 (International Atomic Energy Agency, 2011). The Mecsek mine was the only producer of uranium in Hungary (OECD, 2005). This uranium mine was in ope- ration until 1997 when it was closed due to being uneconomical (Malovics, 2014). Hungary's recent severe accident at tailing impoundment in 2010(Hiller et al., 2016), where large volumes of tailings were discharged directly into the surrounding environment, drew international attention to the need to assure the safety of tailing impoundments(Nagy et al., 2013).Tailings impoundments have poten- tial hazards associated with them, these include stability, rupture, surface and groundwater contami- nation through leaching of PTEs and formation of acid mine drainage (Hiller et al., 2016).The most important information about the Mecsek site is that it is situated very close to the drinking water catchment area, therefore, a very important task is the protection of the groundwater quality (Inter- national Atomic Energy Agency, 2011).

Literature

In this contribution, the application for sequential extraction procedure is reviewed to identify how this procedure can be used for the Ph.D. research to characterize the mobility of PTEs in soil/water system emanating from Mecsek uranium mine in Pecs, Hungary. The goals for the successful characterization is to assess the long-term environmental impact of radioactive contamination of ecosystems, mobility and biological uptake (Skipperud & Salbu, 2015) and evaluating the individual fractions of the PTEs to fully understand their actual and potential environmental effects is helpful to assess the environmental pollution contribution of PTEs (Okoro et al., 2012; Adewuyi & Osobamiro, 2016). After the successful mobility characterization of PTEs in soil/water system, a similar methodology will be adopted to assess the impact of PTEs emanating from gold and uranium mining industries on South Africa`s soil/water system.

Mineral mining has the potential to redistribute the minerals in the adjoining area and if adequate safety measures are not implemented, and may also enhance natural radioactivity (Sahoo, et al., 2010). According to National Research Council of the National Academies (2012), uranium mining poses some unique risks due to the presence of radioactive substances and co-occurring chemicals such as PTEs(e.g., iron (Fe), manganese (Mn), aluminium (Al), selenium (Se), copper (Cu), chromium (Cr), zinc (Zn), lead (Pb), vanadium (V), Molybdenum (Mo), cobalt (Co), or nickel (Ni)). The build-up of PTEs and metalloids in soils and waters continue to create serious global health concerns, as these metals and metalloids cannot be degraded into non-toxic forms, but persist in the ecosystem(Ayangbenro & Babalola, 2017).Such mining activities produce waste rock that may produce acid mine drainage (AMD), due to the presence of sulfides, or it may produce waste that may be clean and stable. Elevated levels of PTEs in soils may increase the mobilization and leaching of the elements that negatively impact agricultural ecosystems(Shaheen et al., 2017), in fact, the toxicity and the mobility of PTEs in the environment depends on their chemical forms (Perin et al., 1997), pH, redox potential, available inorganic and organic ligands (Christophoridis et al., 2009). Potentially toxic elements' chemical form is the key factor in determining their fate. The PTEs' chemical form combines with the environmental factors to influence their mobility or stabi- lity (Rodgers et al., 2015).

Due to the accumulation of metals in sediments from both natural and anthropogenic sources, in the same way, identifying and determining the origin of potentially toxic elements present in the sediments becomes very difficult. In addition, the total concentration of metals often does not accurately represent their characteristics and toxicity. Therefore, evaluating the individual fractions of the metals to fully understand their actual and potential environmental effects will help overcome the above-mentioned obstacles (Okoro et al., 2012). Sequential extraction methods may be used, although more time consuming, to provide more detailed information regarding different metal phase associations, including the mobilization and transport of trace metals (Tessier et al., 1979). To characterize the environmental reactivity of PTEs in fluid (e.g.water) and solid (e.g. soil and sediment) phases, fractionation methods have been applied widely for many years (Rodgers et al., 2015).Despite several problems (e.g. non-selectivity, readsorption, etc.), sequential extraction methodologies are of increasing importance for metal fractionation in order to predict mobility and bioavailability (Filgueiras et al., 2004).

According to Okoro et al. (2012), sequential extraction procedures are operationally defined methodologies that are widely applied for assessing PTE mobility in soils, sediments and waste materials. Potentially toxic elements speciation in environmental media using sequential extraction is based on the selective extraction of PTEs in different materials using specific solvents (Okoro et al., 2012). The determination of the metal speciation is used to assess the environmental impact of soil pollution where more information about the potential release of contaminants and further deri- ved processes of migration and toxicity are given (Ashraf et al., 2011). The sequential extraction methods of soils were developed in order to define the single fractions of elements in soil more precisely (Tlustos et al., 2005). Sequential extraction procedures help to provide important knowledge about the fraction distribution of metals in soils (Saffari et al., 2009) and have become the standard methodology in risk evaluation on PTE contaminations (Heltai et al., 2018). These procedures usually require from three to seven steps, time-consuming and require skilled personnel and adequate analytical instrumentation techniques (Tlustos et al., 2005). Tlustos, et al. (2005) furt- her states that, however, sequential extraction procedures give the most accurate information about fractionation and transformation of elements in soil, especially in relation to soil pollution and long- term effect of soil amendments.

The application for spectrochemical methods e.g. FAAS, ICP-OES and ICP-MS for element de- tection is strongly influenced by the matrix effects caused by the various components of extractant solvents (Heltai et al., 2018).A matrix-matched calibration is required to compensate for matrix effects and therefore, it is a common practice to match the matrix of the calibration standards to that of the samples(Budic, 2000).HACH (2017) states that total metals analysis pretreatment by digestion is required by several procedures for the determination of total metal content in environ- mental samples. The method of digestion ensures the dissolution of the total metal content (Christophoridis et al., 2009). This method uses acid and heat to break organometallic bonds and free ions for analysis (HACH, 2017). Hossner (1996) reported that the dissolution of PTEs in se- diments and soil using concentrated inorganic acids have two advantages, low cost and low salt matrix in final solution for the determination of total heavy metal content. Solutions from digested soil and sediments samples are used for speciation analysis through sequential extraction procedure by using inductively coupled plasma optical emission spectrometry (ICP-OES) and Flame Atomic Absorption Analyst (FAA) (Ashraf et al., 2011).

Materials and methods

Samples will be collected from Mecsek uranium mine in Pecs, Hungary and from the surrounding areas. A controlled laboratory study will be conducted using PTE analysis and radio-analytical methods to determine selected PTE and radionuclides which will enable the assessment of the spre- ad and distribution of these elements from uranium mine tailing to the surrounding areas. Samples will be taken to Szent Istvan University (SZIU) laboratories for PTE analysis and radio-analytical analysis.

*Sample type:*Water, soil/rock (ore)/sediment and vegetation.ample preparation:

*Sample area:*Mecsek Uranium mine and surrounding areas.

Sample preparation:

- Total or pseudo total elemental content by digestion
- Fractionation(sequential extraction procedure)
- Speciation analysis of detectable toxic elemental form (e.g. Cr VI)

Instrumental analysis method for potentially toxic elements analysis:

- Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)
- Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
- Flame Atomic Absorption Spectroscopy (FAAS)

Instrumental analysis methodology for radionuclides analysis:

- Gamma spectroscopy with HPGe detector
- Alpha spectroscopy - for Radon analysis

Expected results

Sequential extraction can characterize the mobility of PTEs in soil/water system. Data from spect- rochemical methods will be used to identify the risks associated with PTEs from mines. This study can contribute towards the improvement of the controlledmethodology of remediation procedure on an abandoned uranium mine in Hungary and improve water management opportunities while eliminating threats.

Conclusion

This research will give an indication onthe ability to chemically speciate toxic components, with regards to phase association(Rodgers et al., 2015),whichallows for better prediction and understanding of an element's environmental fate and potential impact(IUPAC, 2000). Knowledge about the fateof PTEs in the ecosystem is required to answer both scientific and practical questions regarding the protection of groundwater and plants, sustainable management of soils, or to explain the pathways of environmentally harmful substances(Shaheen et al., 2017).The methodology to be developed should be applied to other sites in South Africa.

Summary

Uranium and gold mining remediation processes have the potential to redistribute the potentially toxic elements (PTEs) in the adjoining area and if adequate safety measures are not implemented, and may also enhance natural radioactivity. These activities may negative impacts on the environ- ment, particularly on soil/water systems. Therefore, necessary measures need to be taken with regards to the protection of surface and groundwater and sustainable management of soils. Whilst the decreasing quantity of water has been a concern for decades, more recently these concerns have been compounded by water quality issues resulting from water pollution, including PTEs and radio- active nuclides contaminants.

In this paper, the remediation problems of abandoned uranium and gold mines are described. The aim of the Ph.D. research is elaboration and application of methodologies which are able to charac- terize the risks connected with remediation of abandoned Mecsek uranium mine in Hungary.After the successful characterization of PTEs in soil/water system, a similar methodology will be adopted to assess the impacts of PTEs emanating from gold and uranium mining industries on South Afri- ca`s soil/water system.In this research, the potential of sequential extraction procedures, Instru- mental analysis methodology for radionuclides and spectrochemical methodologies (e.g. Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Flame Atomic Absorption Spectroscopy (FAAS))are discussed which can characterise the environmental mobility of potentially toxic elements and radioactive nuclides in the soil/water system.

These procedures usually require from three to seven steps,time-consuming and require skilled personnel and adequate analytical instrumentation techniques.Sequential extraction methods will be used,although more time-consuming,to provide more detailed information regarding different metal phase associations, including the mobilization and transport of trace metals.Data from spectrochemical methods will be used to identify the risks associated with PTEs from mines. This study can contribute towards the improvement of the controlled methodology of remediation procedure on an abandoned uranium mine in Hungary and improve water management opportunities while eliminating threats.

Keywords: Sequential extraction, spectrochemical methods, potentially toxic elements, soil, water.

Acknowledgments

The authors would like to acknowledge Stipendium Hungaricum andSouth African Department of Higher Education And Training for the financial support.

References

Adewuyi G.O. – Osobamiro M.T.: 2016. Research Article Chemical Speciation and Potential Mobility of Some Toxic Metals in Tropical Agricultural Soil. Research Journal of Environmental Toxicology, 10(3), pp.159–165. Available at: http://dx.doi.org/10.3923/rjet.2016.159.165.

Ashraf M. A. – Maah M. J.– Yusoff I.: 2011. Chemical Speciation and Potential Mobility of Heavy Metals in the Soil of Former Tin Mining Catchment. The Scientific World Journal, 1-12.

Ayangbenro A. – Babalola O.: 2017. A new strategy for heavy metal polluted environments: a review of microbial biosorbents. Int. J. Environ. Res. Public Health 14:94. doi: 10.3390/ijerph14010094.

Budic B.: 2000. Matrix interferences in the determination of trace elements in waste waters by inductively coupled plasma atomic emission spectrometry with ultrasonic nebulization. Fresenius' journal of analytical chemistry, 368(4), pp.371–7. Available at: http://www.ncbi.nlm.nih.gov/pubmed/11227506.

Christophoridis C.– Dedepsidis D. – Fytianos K.: 2009. Occurrence and distribution of selected heavy metals in the surface sediments of Thermaikos Gulf, N. Greece. Assessment using pollution indicators. Journal of Hazardous Materials, 168(2–3), pp.1082–1091.

Filgueiras A. V. – Lavilla I. – Bendicho C.: 2004. Evaluation of distribution, mobility and binding behaviour of heavy metals in surficial sediments of Louro River (Galicia, Spain) using chemometric analysis: A case study. Science of the Total Environment, 330(1–3), pp.115–129.

HACH: 2017, May 27. How should a sample intended for total metals analysis be digested? Retrieved October 30, 2017, from HACH: http://www.hachcompany.custhelp.com

Heltai G. – Gyori Z. – Fekete I. – Halasz G. – Kovacs K. – Takacs A. – Boros, N. – Horvath M.: 2018. Longterm study of transformation of potentially toxic element pollution in soil/water/sediment system by means of fractionation with sequential extraction procedures. Microchemical Journal, 136, pp.85–93.

Hiller E. – Toth R. – Kucerova G.– Jurkovic L. – Sottnik P.– Lalinska-Volekova B. – Vozar J.: 2016. Geochemistry of Mine Tailings from Processing of Siderite–Cu Ores and Mobility of Selected Metals and Metalloids Evaluated by a Pot Leaching Experiment at the Slovinky Impoundment, Eastern Slovakia. Mine Water and the Environment, 35(4), pp.447–461. Available at: http://link.springer.com/10.1007/s10230-016-0388-2.

Hossner L. R.: 1996. Dissolution for Total Elemental Analysis. In D. L. Sparks, Methods of soil Analysis. Part 3, Chemical Methods (pp. 49-64). Madison: Madison, Wis. : Soil Science Society of America : American Society of Agronomy.

International Atomic Energy Agency: 2011. The Uranium Mining Remediation Exchange Group (UMREG). Vienna: IAEA Publishing.

IUPAC: 2000. Guidelines for the terms related to chemical speciation and fractionation of elements. Definitions, structural aspects, and methodological approaches. Pure and Applied Chemistry, 72, 1453-1470.

Keith S. – Doyle J. R. – Harper, C.: 2012, May 7. ANALYTICAL METHODS - Toxicological Profile for Radon. Retrieved November 20, 2017, from NCBI: https://www.ncbi.nlm.nih.gov/books/NBK158779/

Liefferink M.: 2014. Uranium Mining in South Africa: Environment and Human Rights. Uranium Mining Impact on Health & Environment (pp. 30-35). Dar es Salaam: Rosa Luxemburg Stiftung.

Malovics G.: 2014, 04 08. Uranium mine opening in Pecs, Hungary. Retrieved 09 24, 2017, from Ejatlas.org: http://ejalas.org/conflict/uranium-mine-reopening-in-pecs-hungary

Nagy A.S.– Szabó J. – Vass I.: 2013. Trace metal and metalloid levels in surface water of Marcal River before and after the Ajka red mud spill, Hungary. Environmental Science and Pollution Research, 20(11), pp.7603–7614.

National Research Council of The National Academies: 2012. Uranium Mining in Virginia. Washington, D. C. The National Academies Press.

National Water Programme of the Hungarian Academy of Sciences.: 2017, June 14. Water in Hungary - Status overview for the National Water Programme of the Hungarian Academy of Sciences. Budapest. Available at: http://mta.hu/data/dokumentumok/Viztudomanyi

Program/Water_in_Hungary_2017_07_20.pdf.

OECD: 1999. Environmental Activities in Uranium Mining and Milling. Paris, France: OECD Publications Service.

OECD: 2005. Uranium 2005: Resources, Production and Demand. Paris, France: OECD Publications.

Okoro H.K.– Fatoki O.S.: 2012. A Review of Sequential Extraction Procedures for Heavy Metals Speciation in Soil and Sediments. Journal of Environmental & Analytical Toxicology, 1(S1), pp.1–9. Available at: https://www.omicsonline.org/scientific-reports/srep181.digital/srep181.html.

Perin G. – Fabris R. – Manente S. – Wagner Rebello A. – Hamacher C.– Scotto S.: 1997. A five- year study on the heavy-metal pollution of Guanabara Bay sediments (Rio de Janeiro, Brazil) and evaluation of the metal bioavailability by means of geochemical speciation. Water Research, 31 (12), pp. 3017-3028

Rodgers K.J. – Hursthouse A. – Cuthbert S.: 2015. The potential of sequential extraction in the characterisation and management of wastes from steel processing: A prospective review. International Journal of Environmental Research and Public Health, 12(9), pp.11724–11755.

Saffari M. – Yasrebi J. – Karimian N. – Shan X.: 2009. Evaluation of Three Sequential Extraction Methods for Fractionation of Zinc in Calcareous and Acidic Soils. Research Journal of Biological Sciences, 4(7), 848-857.

Sahoo S. K. – Mohapatra S. – SethyN. K. – Patra A. C. – Shukla A. K. – Kumar A. V. – Tripathi R. M. – Puranik V. D.: 2010, March 19. Natural radioactivity in roadside soil along Jamshedpur-Musabani Road: A mineralised and mining region, Jharkhand and associated ris. Radiation Protection Dosimetry, 140(3), 281-286.

Shaheen S.M. – Tsadilas C. D. – Ok Y. S. – Rinklebe J.: 2017. Potential Mobility, Bioavailability, and Plant Uptake of Toxic Elements in Temporary Flooded Soils. Trace Elements in Waterlogged Soils and Sediments, pp.313–328.

Skipperud L.– Salbu B.: 2015. Sequential extraction as a tool for mobility studies of radionuclides and metals in soils and sediments. Radiochimica Acta, 103(3), 187-197.

Tessier A.– Campbell P.G.C. – Bisson, M.: 1979. Sequential Extraction Procedure for the Speciation of Particulate Trace Metals. Analytical Chemistry, 51(7), pp.844–851.

The Atomic Energy Corporation of South Africa Limited.: 1988. Uranium in South AFrica. Pretoria: The Atomic Energy Corporation of South Africa Limited.

Tlustos P. – Szakova J. – Starkova A.– Pavlikova D.: 2005, July 19. A comparison of sequential extraction procedure for fractionation of arsenic, cadmium, lead, and zinc in soil. Central European Journal of Chemistry, 3(4), 830-851.

Visser D. – Reid E.: 2013. Private Law and Human Rights: Bringing Rights Home in Scotland and South Africa. Edinburgh University Press ISBN 13: 9780748684175 ISBN 10: 0748684174

Winde F.: 2011. Karst, Uranium, Gold and Water – Lessons from South Africa for Reconciling Mining Activities and Sustainable Water Use in Semi-arid Karst Areas: A Case Study. In: Jones J. (eds) Sustaining Groundwater Resources. International Year of Planet Earth. Springer, Dordrecht.

Winde F. – Stoch E.J.: 2010. Threats and opportunities for post-closure development in dolomitic gold-mining areas of the West Rand and Far West Rand (South Africa) - A hydraulic view Part 2: Opportunities. Water SA, 36(1), pp.75–82.

Characterization of mobility of potentially toxic elements in soil-water system by sequential extraction procedures

Abstract

In this paper, the remediation problems of abondoned uranium and gold mines is described. The aim of the PhD research is elaboration and application of methodologies which are able to characterise the risks connected with remediation of abandoned Mecsek uranium mine in Hungary. After the succesful characterisation of PTEs in soil/water ststem, similar methodolgy will be adopted to as- sess the impacts of PTEs eminating from gold and uranium mining industries on South Africa`s soil/water system. In this research, the potential of sequential extraction procedures and spectroc- hemical methodologies (e.g. Inductively Coupled Plasma Optical Emission Spectrometry (ICP- OES), Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Flame Atomic Absorption Spectroscopy (FAAS)) are discussed which can characterise the environmental mobility of potentially toxic elements and radioactive nuclides in the soil/water system. Data from spectrochemical methods will be used to identify the risks associated with PTEs from mines. This study can contribute towards the improvement of the controlled methodology of remediation procedure on abondoned uranium mine in Hungary and improve water management opportunities, while eliminating threats.

Keywords: Sequential extraction, spectrochemical methods, potentially toxic elements, soil, water.

WATER CYCLE RECOVERY: AN AGROFORESTRY APPROAC

Marques Maria Aparecida [1] – Törőné Dr. Dunay Anna [2]

1 Szent István University, Hungary, e-mail: mariamarquesadm@gmail.com
2 Szent István University, Hungary, e-mail: dunay.anna@gtk.szie.hu

Abstract

Agroforestry system is explored in many research areas and check the relevance for the environ- ment in the different aspect. In this context, this article has been exploring the agroforestry relevan- ce in aspect hydrological of water cycle maintenance. In the water cycle, it was more explored the interaction the shade trees in infiltration and runoff aspect and how can get vertical and deep water through roots.

Introduction

The water cycle is intensively exploited by researchers because is a resource elementary for life on earth. It is like a closed system and many points research water shows that on the water planet the water must be preserved because the time it takes to produce water naturally is high and maybe, we will haven't enough time.

Natural resources conservation is very related to food security and maintenance human life. The aim of this research is to demonstrate the potential of Agroforestry system to the regeneration of the natural resources and maintenance of food security. Through return of natural water cycle in the system. It can be explored in a simple and succinct way.

In this case, the water infiltration it is relevant to the research because it is ensured that will have water in the future.

Water interaction with land covers

Besides rivers and lakes, there is underground water. And these reserves are the most important for the earth life. These reserves are constantly renewing through of infiltration. Part of water that infilt- rates will remain in the shallow soil layer, where it will gradually move vertically and horizontally through the soil and subsurface material. Some of the water may infiltrate deeper, recharging gro- undwater aquifers. The structure and function of the water reserver are regulated by complex hydro- logical and ecological processes operating at different spatial and temporal scales (Ward, 1989; Wiens, 2002 apud Paula et al. 2017).

Southern Australian has a dramatic reality hydrological. It is the due to low hydrological gradients and high evaporation relative to rainfall. This result a dry soil and stress vegetation and it were checking a relation as a landscape modification during the years when the agriculture gets the forest space. Hatton and Nulsen (1999) concluded, about resulting of hydrological change in Australia, that was with changing land-use that started the soil degradation. Being also, impossible to recover the original in the scale of the tree planting required to significantly restore the natural water balan- ce.

In another study in Australia that concluded about efficiency, feasibility, and profitability of agrofo- restry system. In that case, agroforestry was therefore to be an effective solution water management and the trees has been competing directly on commercial terms with conventional agriculture (LEFROY and STIRZAKER 1999).

The capacity of the water infiltration, in general, depends of the soil type, the properties itself and the cover layer. The vegetation is the first contact and litter is the second contact. Those layers can provide erosion control by protecting the soil against raindrop impact, reduce runoff velocity by increasing surface roughness and water infiltration as well as providing tree roots that create chan- nels to water in the soil (Ranieri et al. 2004 apud Tscharntke et al. 2011). Agroforestry can be un- derstood by multilayer canopy with mix vegetation species. Besides the water and nutrient competi- tion, there is synergy between the species and this ends in theas positive balance as demonstrated by

Köhler et al. (2009) apud Tscharntke et al. (2011), that shade trees reduce evaporative demand and, hence, drought stress of cacao plants.

In the article of the Karvonen et al. (1999) have been modeling the relationship between runoff and land use. This was explored early by Palko and Weppling (1995) the interaction temporal of runoff. And after checking many research Karvonen et al. (1999) concluded that different land use types have to be taken into account because have a different contribution of runoff and in soil infiltration.

Deep roots and surface water

A study in a cocoa ⁄ Gliricidia agroforestry in Sulawesi, for example, proved that the increased canopy cover from shade trees has been shown to enhance water uptake and increase cacao stem diameter and leaf area (Köhler et al. 2009 apud Tscharntke et al. 2011). Ong, Kho & Radersma (2004) apud Tscharntke et al. (2011), demonstrate positive effects and complementary resource use in agroforestry systems.

Complementary, the root system in cocoa trees species generally use water from the upper soil layer, and Gliricidia shade trees, generally, uses water from deeper soil layers (Schwendenmann et al. 2010). It proved, in case of this two species that have a synergy between them. The cacao specie tends to have more dense roots in the upper soil layers. And the Gliricidia deep root system, in the use of the water resource, bring up and redistribute water in the upper soil layers for the cacao root zone. It translates into sustainable resource use and higher yields in shaded cacao agroforestry, also promoting a reduction in the water irrigation (Ewel & Mazzarino 2008 apud Tscharntke et al. 2011).

The positive outcome will depend on environmental and the producer's planting choices. The determinations that how to do a complex system needs the deeper knowledge of the land and the shade tree specie and its role among crops, so at the end, the system tends to a positive balance. The study review of Tscharntke et al. (2011) concludes that implement certification schemes is likely most effective when it involves a transfer of knowledge between farmers and' scientists. It can improve the shade tree management Indeed.

Schwendenmann et al. (2010) concluded in studies that shade tree can water uptake vertically with fine roots and this interaction between cacao and Gliricidia provides water and nutrient for superficial roots. In this case, shows a positive interaction between a productive tree and shade tree in the Agroforestry system in dry soil conditions when roots go in deeper layers.

Conclusions

In this research, could explore that shade trees can have a positive interaction with the crop. There are many types of research proving that deep roots can get deep water and distribution in shallower layers of soil, like the vertical and horizontal interaction between the roots in the dry soil. Agrofo- restry system, in this case, has a high participation because can provide a new way for crops in dry soil. Some land covers have an impact on infiltration and rainfall runoff. The trees and vegetation can slow down the movement of runoff, allowing more time for it to seep into the ground. In the runoff case, the shade trees can reduce because have more biomass distribution in soil and this can do also high water infiltration.

Keywords: Water infiltration, runoff, and deep water.

Acknowledgements

This study was conducted with the funding from the Stipendium Hungaricum and Szent István University - MKK.

Citation

HATTON, T. J.; NULSEN, R. A. Towards achieving functional ecosystem mimicry with respect to water cycling in southern Australian agriculture. Agroforestry Systems, v. 45, n. 1–3, p. 203– 214, 1999.

KARVONEN, T. et al. A hydrological model for predicting runoff from different land use areas. [s.d.].

LEFROY, E. C.; STIRZAKER, R. J. Agroforestry for water management in the cropping zone of southern Australia. Agroforestry Systems, v. 45, p. 277–302, 1999.

PAULA, F. R. DE et al. Multi-scale assessment of forest cover in an agricultural landscape of Southeastern Brazil: Implications for management and conservation of stream habitat and water quality. Ecological Indicators, v. 85, p. 1181–1191, 2017.

SCHWENDENMANN LUITGARD, EDZO VELDKAMP, GERALD MOSER , DIRK HÖLSCHER, MICHAEL KÖHLER, YANN CLOUGH, ISWANDI ANAS, GUNAWAN DJAJAKIRANA, STEFAN ERASMI , DIETRICH HERTEL, DANIELA LEITNER, CHRISTOPH LEUSCHNER, BEATE MICHALZIK, PAVEL PROPASTIN, AIYEN TJOA, T. T. AND O. VAN S. Effects of an experimental drought on the functioning of a cacao agroforestry system, Sulawesi, Indonesia. p. 1515–1530, 2010.

TSCHARNTKE, T. et al. Multifunctional shade-tree management in tropical agroforestry landscapes - A review. Journal of Applied Ecology, v. 48, n. 3, p. 619–629, 2011.

EXAMINATION OF THE DRIVER'sFOCUSING SCHEME DURING PRECISION AgRICIULTURAL OPERATION

I. SZABÓ [1] – M. HUSHKI[1] – Z. BÁRTFAI[1] – L. KÁTAI[1] – A. LÁGYMÁNYOSI[1]

1 SzentIstván University,
Faculty of Mechanical Engineering, Institute of Mechanics and Machinery,
Páter K. Street 1., 2100 Gödöllő, Hungary,
e-mail: lagymanyosi.attila@gek.szie.hu

Abstract

Operator's workplace design takes a priority to be developed in order to reach the highest possible level of Quality, Safety and productivity. The multi-tasking off road vehicles industry design and development process requires dependable and deterministic measures to decide about the tools and equipment in which the new enhancement is ensured to be valuable and reliable using the state of the art engineering solutions. This research is made based on literature of the accumulated knowledge from different studies and analysis are made to provide the necessary input for Human Centred Design process. The results of this research are demonstrating the change on operator's focusing scheme inside a multi-tasking off-road vehicle along working hours for a selected area of interest which is the attached tool for the multi-tasking vehicle.

Introduction

Human-centred-design approach is considered one of the most effective factors enhancing the productivity of vehicles used in the industrial and agricultural fields. The development of operator's workstation needs to be based on deterministic data which is validated, verified and dependable.

Tractors are companions for many agriculture workers. Well-designed human – tractor interfaces, such as well-accommodated tractor operator enclosures can enhance operations productivity, comfort and safety (Matthews, 1977), (Kaminaka et al., 1985), (Liljedahl et al., 1996) and (Hsiao et al., 2005).

Many studies have been carried on to find preferred locations of in certain types of tractor controls (Casey & Kiso, 1990), moreover; emphasizing how critical is the placement of controls in some tractors stating that; it actually creates an impediment to body movement (Hsiao et al., 2005).

Driving is not only a physical task but also visual and mental tasks. The eyes of a driver are indispensable in performing visual tasks such as scanning the road, and monitoring in-vehicle devices.

A study conducted in 2015 by Gonçalves &Bengler claims that Highly Automated Driving (HAD) will be commercially available in a near feature, yet human factors issues like the influence of driver state can have a critical impact in the success of this driving paradigm and also in road and field safety.

For the purpose of this research, we focus on measuring the focusing scheme of the operator inside the tractor cabin in the lining operation showing by durations the time spent by the operator focusing on selected areas of interest and its change along working hours.

Materials and methods

To the purpose of this research, the processes is limited to the data extraction and analysis. The followed methodology is summarized in process map showed in (Fig. 1) However; the scope is subjected to be extended upon the accomplishment of theall research phases to test new design enhancements and engineering solutions.

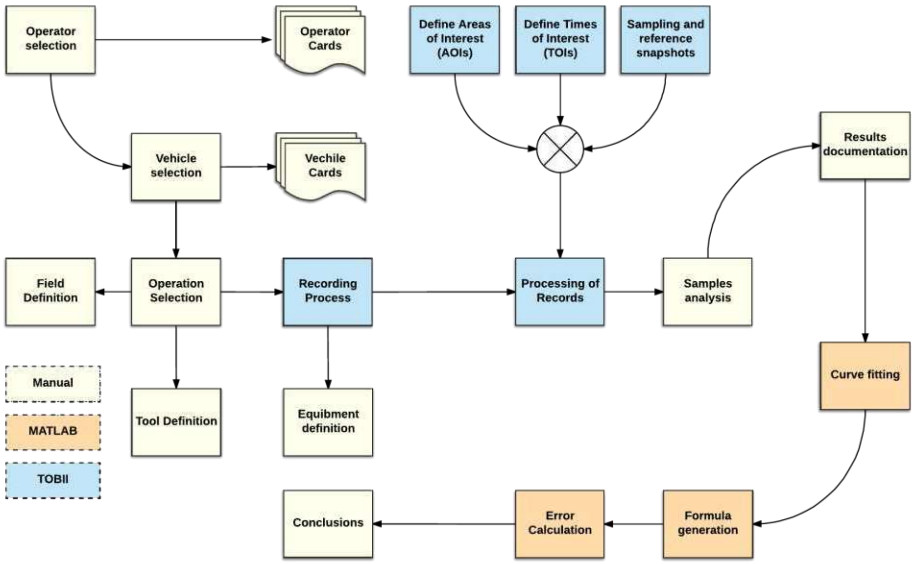


Figure 1. Methodology process map

Selection of vehicle

CLAAS tractor (Model: ARES 567 ATZ) is selected to the purpose of accommodating the experimental trials This model has a covered workplace for the operator, which is helpful to control some of experimental conditions (i.e. temperature and humidity) keeping on the consistency of those parameters and conditions.

Selection of experimental field
Experimental trials are conducted under the supervision of SzentIstván University management in a field called by Babat-völgy to the north west of Gödöllő.

Selection of operation and attached tool
Lining agricultural operation is selected to be the studied operation in this research. After hay cutting in the agricultural field, lining operations are conducted to sort hay into lines in the field. The operation is conducted by specific tools attached to tractors generating hay lines in order to prepare for the hay baling operation. To the purpose of this research, the used attached tool to the CLAAS tractor (Model: ARES 567 ATZ) is CLAAS LINER 450T

Tobii Glasses 2 equipment
Tobii Glasses 2 (Fig. 2) is used to the purpose of obtaining the operator's focusing scheme from his real-time gaze analysis to predefined areas of interest. Which is feeding the research results with the main source of data regarding the target behaviour to be studied. The equipment and its applicability was introduced in authors earlier paper (Szabó et.al. 2017).

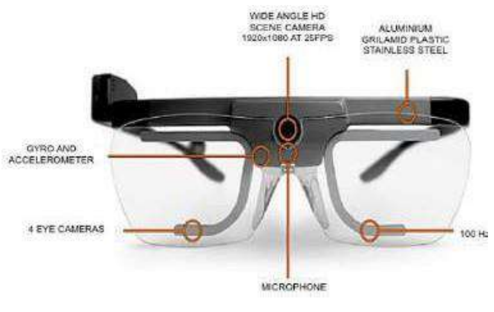


Figure 2. Tobii glasses 2

Controller software

To record eye tracking data, the Tobii Glasses head unit must be fitted onto the test operator's head (similar to a standard pair of glasses). The system must then be calibrated separately for each participant. Tobii Glasses Controller Software running on a Windows 8/8.1 Pro tablet or any Windows 8/8.1 or 7 computer.

Processing of raw data

The main processing tool of the operators' gazes is the Tobii Pro Lab which has a powerful post-analysis and visualization tools provide a full spectrum of qualitative and quantitative gaze data analysis and visualizations. Tobii Pro Lab logs events, defines areas of interest, calculates statistics, creates heat maps, and exports data for further analysis in other software.Tobii Pro Studio has three different types of fixation filters to group the raw data into fixations and Tobii Pro Lab uses one type of fixation filter to process the data. These filters are composed of algorithms that calculate whether raw data points belong to the same fixation or not.

Areas of interest (AOIs) and reference snapshot

The area of interest is a concept and a Pro Lab tool that allows the eye tracking researcher or analyst to calculate quantitative eye movement measures. These include fixation counts and durations. To the purpose of this research, the selected area of interest is the attached tool. Reference snapshot is taken for the item in the area of interest form the video recorded by the Tobii Glasses 2 equipment.

Results and discussion

Experimental procedure

An operator is selected to wear the Tobii Glasses 2 equipment which is connected to the central device running Tobii controller software by which the calibration process of operator focusing is conducted and recording process is controlled.

The used tractor (CLAAS Model: ARES 567 ATZ) is located to the operational field (Babat-völgy) attached to the lining tool (CLAAS LINER 450T) conducting the hay lining agricultural operation. The selected area of interested (AOI) is defined to be the attached lining tool.

The operator is mandated to go through the calibration process, start the recording process and get in the tractor cabin for conducting the hay lining operation along 6600 working seconds.

Thereafter; the recording process is stopped. And the recorded video is processed by the Tobii Lab pro software using the automatic real world mapping tool, which took about 86 working hours. Heat maps representing operator's focusing scheme during the recording time are generated by the software, which leads to generate the statistic readings using MS Excel software.

The obtained data is Normalized in accordance to the formula: Normalized snap time of (X) sample = Normalization factor (N) * Actual snap time of (X) sample. And resulted data is processed using the MATLAB Curve Fitting Toolbox™ to obtain the representing formula for the change on Operator's focusing scheme inside a multi-tasking off-road vehicle along working hours.

Results

Wearing the Tobii Glasses 2 which was connected to the Tobii controller software, after the calibration process, the operator was mandated to proceed conducting his regular tasks in hay lining using the tractor and the attached lining tool. Thereafter; the analysis process was started on the recorded video using Tobii Pro Lab software.

After accomplishing the analysis process, the resulted data was exported by the same software to MS Excel sheet. The samples were normalized in accordance to the mentioned normalization for- mula.

The exported results (Table. 1) showed:

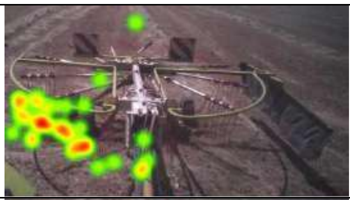
Sample Reference	X value	Tool Snap time (Sec)	N Factor	Time (weighted) (Sec)	Generated Heat map
8	1	7.09	1.00	7.09	
9	2	2.15	1.00	2.15	
10	3	15.17	1.00	15.17	

Table 1. Some experiment results

Thereafter; the curve fitting operation is conducted using the MATLAB Curve Fitting Toolbox™, the resulted curve (Fig. 10) was processed selecting the Linear model

$$F(x) = - 2.814\ x^2 - 1.21\ x + 10.21$$

which generates a polynomial equation with the second degree and using Bisquare robust method.

The resulted model and the goodness of fit is shown, which gave the final equation:

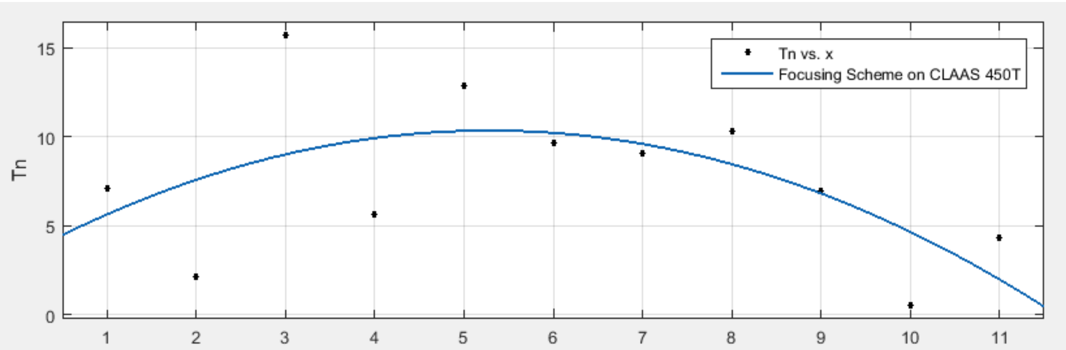


Figure 3. Curve fitting of results

Discussion

The results showed very accurate and dependable data of the operators gaze on selected area of interest. The used equipment and supporting software packages easily defined the time in which the operator paid his attention to the attached lining tool during working time in the lining operation.

The analysis of the recorded sample from lining agricultural operation showed that; clearly; the operator focusing scheme is decreasing along working hours which is related to the increment of physical and mental load as the time of the agricultural operation conducting.

Conclusions

The methodology used to generate deterministic results which are validated, verified and dependable to represent the operator's behaviour of the focusing scheme inside the workplace (tractor cabin).

The variety of filters and options available under the scope of the analyser software capability is found convenient to come over expected challenges during further research activities such as in- field experiments and outdoors activities.Such generated results confirmed the feasibility of invest- ing the followed methodology in studying more AOIs inside the tractor cabin to feed the design and/or development processes of the tractor cabin with valuable input data beside the conventional user experience feedback and continual research and development channels.

Additionally; the physical load is expected to be reduced by installing a video screen to the dashboard broadcasting live videos of the lining attached tool. And is expected as well to spare the time and physical effort spend on by the operator for checking the parameters of the tractor and the attention planned track direction.

Acknowledgments

This publication is created in number EFOP-3.6.1-16-2016-00016 The specialise of the SZIU Campus of Szarvas research and training profile with intelligent specialization in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production

References

Casey, S.M., & Kiso, J.L. 1990. The acceptability of control locations and related features in agricultural tractor cabs. In Proceedings of the Human Factors Society 34th annual meeting (Santa Monica, CA: Human Factors Society). 743 – 747.

Gonçalves J. &Bengler K. 2015. Driver State Monitoring Systems– Transferable knowledge manual driving to HAD, AHFE.

Hsiao, H., Whitestone, J., Bradtmiller, B., Whisler, R., Zwiener, J., Lafferty, C., Kau, T.Y. & Gross, M. 2005. Anthropometric criteria for design of tractor cabs and protection frames. Ergonomics, 48. 323-53.

Kaminaka, M.S. 1985. Research needs in the American agricultural equipment industry. Applied Ergonomics, 16.3. 217 – 220.

Kramer, A. 1990. Physiological metrics of mental workload: A review of recent progress. In D. Damos, (Ed.). 2015. Multiple-task Performance, London: Taylor & Francis. 279-328.

Liljedahl, J.B., Turnquist, P.K., Amith, D.W. &Hoki, M. 1996. Tractors and Their Power Units, pp. 226 – 231 (St. Joseph, MI: American Society of Agricultural Engineers).

Louw, T., &Merat, N. 2017. Are you in the loop? Using gaze dispersion to understand driver visual attention during vehicle automation. Transportation Research Part C 76 (2017). 35–50.

Marquart, G., Cabrall, C., & Winter, J. 2015: Review of eye-related measures of drivers' mental workload. Procedia Manufacturing 3 (2015). 2854 – 2861.

Matthews, J. 1977. The ergonomics of tractors. ARC Research Review, 3. 59 – 65.

Saxby, D. J., Matthews G., Warm J. S., Hitchcock E. M. & Neubauer, C. 2013. Active and passive fatigue in simulated driving: discriminating styles of workload regulation and their safety impacts. J. Exp. Psychol. Appl. 19 (4), 287–300.

Shen S., &Neyens, D. M. 2017. Assessing drivers' response during automated driver support system failures with non-driving tasks. Journal of Safety Research 61, 149–155.

Szabó, I., Hushki, M., Bártfai Z., Kátai L. 2017. Operator's behaviour measuring methodology inside off-road vehicle cabin, Operator's focusing scheme. Agronomy Research, 15. https://doi.org/10.15159/AR.17.033

Keywords: off-road vehicle, measuring operator's focusing scheme, eye tracking, lining operation

THE CHALLENGES AND PROSPECTS OF WATER RESOURCE MANAGEMENT IN ETHIOPIA

T. G. Weldmichael1, B. Simon2, E. Micheli2

1Addis Ababa Science & Technology University, Ethiopia, tsedyweld@gmail.com
2Szent István University, Hungary, Simon.Barbara@mkk.szie.hu ; micheli.erika@mkk.szie.hu

1. Introduction

Water has always played a central role in Ethiopian society. It is an input, to a greater or lesser extent, to almost all production. The economy of Ethiopia and majority of the people's livelihoods are dependent on agriculture. Rainfed agriculture accounts 90% of the export, 85% of employment and 47% of the GDP (World Bank, 2006). Ethiopia is endowed with adequate average annual rainfall, several major rivers and lakes, and significant groundwater resources (Birhane et al.2016). In spite of being relatively rich in water and land resources, Ethiopia is unable to produce reliable food supply. Extensive land degradation and deforestation coupled with erratic water distribution both in space and time are the major causes of the problem. The adverse impacts on water resources have occurred due to the large demands of an ever-increasing human population, which are further aggravated by poverty (Desta and Lemma, 2017).

The Ethiopian government has recognized water as major component in the economic development and poverty reduction (Awulachew, et al. 2010). Accordingly, efforts and investments have been done in Ethiopia to increase the irrigated area, on community-based soil and water conservation practices and hydropower developments. However, this water centered development is seriously constrained by a complex water legacy and lack of access to, and management of, water resources. The rainfall regime in Ethiopia is highly unreliable and unevenly distributed. Ethiopia's extreme hydrological variability is echoed in its economic performance, as the economic productivity and the welfare of the people linked to the volatile and erratic rains (Birhane et al. 2016). For instance, the 2002/2003 drought has cost Ethiopia with negative 3.3% GDP growth (Awulachew, et al. 2010). With poor agronomic and water management practices, relatively weak management institutions and capacity, inadequate water storage capacity, and poor water monitoring system, Ethiopia faces an enormous challenge to achieve water and food security. Thus, this paper assesses the challenges and prospects of water resource management, and forward future directions for the sustainable wa- ter resource management in Ethiopia.

2. Ethiopia's water resources

Ethiopia is endowed with ample water resources in central, western and southwestern parts, while most of north eastern and eastern parts of the country are relatively dry. The country has 12 major river basins, 11 fresh and 9 saline lakes, 4 crater lakes, and over 12 major swamps or wetlands (Awulachew, 2007). The annual runoff water volume and groundwater resources are estimated at 122 billion m^3 and 2.6 billion m^3 respectively. The estimated per capita renewable freshwater reso- urces of 1,900 cubic meters indicates an abundance of water (MoWR, 2002). However, due to lack of water storage infrastructure and large spatial and temporal variations in rainfall, there is not eno- ugh water for most farmers to produce more than one crop per year (Awulachew, 2007). The hydro- logy of Ethiopia is highly influenced by its highly varied topography. Abbay, Baro-Akobo, Omo- Gibe river basins, are the main contributor to the surface runoff water. Ethiopia has a number of lakes, most of which are found within the rift valley, that are central for socio-economic develop- ments. Lake Tana, with an area of 3,600 square kilometers, is the largest of 15 natural lakes in Ethiopia (Akele, 2011). Most of the lakes except Ziway, Tana, Langano, Abbaya, and Chamo have no surface water outlets.

3. Challenges of water management in Ethiopia

3.1. Hydrological variability

Ethiopia's primary water resource management challenges are its extreme hydrological variability and seasonality and the international nature of its most significant surface water resources (World Bank, 2006). The water resource is not evenly distributed by season and location, and only 3% of it remains in the country (Chukalla, et al. 2013). Ethiopia's rainfall shows high spatial and temporal variability. The mean annual rainfall ranges between 2,700 millimeters in the southwestern highland to less than 100 millimeters in northeast lowlands. In addition, 50%–80% of annual rainfall total falling in a single short season during June–September, and also differs vastly from year to year in timing and total amount (Korecha and Barnston, 2007). Due to this erratic nature of rainfall distribu- tion some parts of the country have suffered from famine associated with insufficient rain, while other parts have experienced heavy flood (Woube, 1999).

3.2. Land degradation and deforestation

Land-use and water-use are inseparable, as 98% of the rainfall passes over or through land on its way. Deforestation, rapid land-use change for farming, and overgrazing are likely to affect the hydrologic regime of water bodies. Conversely, hydrology plays a pivotal role in erosion, land deg- radation, reduced soil fertility and productivity, and siltation. Land degradation is a major problem in Ethiopia. It has a negative impact on agricultural economy and the natural environment (Hishe, et al. 2017). Population growth, severe deforestation, and traditional agricultural practices of cultivat- ing steep slopes without protective measures are the principal causes of increased runoff and soil erosion in the country which resulted in declining agricultural productivity, water scarcity and con- tinuing food insecurity. Annually Ethiopia loses over 1.5 billion tons of topsoil from the highlands by erosion. This could have added about 1–1.5 million tons of grain to the country's harvest (Tades- se, 2001). Earlier studies have estimated the cost of land degradation to be between 2.0 and 6.75 percent of Ethiopia's agricultural GDP per annum (Schmidt and Zemadim, 2015). The present level of deforestation in Ethiopia is about 150,000–200,000 ha of forest per year. The loss of forest cover, in turn, resulted in the increase of the silt and nutrient load of the water (Devi et al. 2008; Nyenje et al. 2010). Associated sedimentation causes detrimental effects on water infrastructure, municipal water supplies, agriculture and hydropower generation (World Bank, 2006). Studies also reported that Lakes Chamo and Abiyata are significantly affected by eutrophication problem due to nutrient load in the water (Zinabu, 2002). The consequence of deforestation and degraded soil structure comprises less infiltration of rainfall and reduced water storage capacity in the soil (World Bank, 2006).

3.3. Excessive water abstraction

Most of the rift valley lakes were the focal points for relatively large-scale water resources deve- lopment due to their volcano-tectonic depressions with highly variable hydrogeological setting (Ayenew, 2007). Some of these lakes are being used for commercial fishing, irrigation, soda ash extraction and recreation. However, excessive extractions, intractable human interactions with natu- re and extensive development activities have led significant changes in their state (Akele, 2011). Water abstraction is often being done without the basic understanding of the complex hydrological and hydrogeological system and the fragile nature of the rift ecosystem. The most important large- scale withdrawals of water in the rift are related to irrigation and trona (Na_2CO_3) production. These activities have shrunk the water level of some lakes and affected the hydrochemical settings. Beside the anthropogenic factors, the occurrence of frequent earthquakes and formation of new faults might have influenced hydrogeologic regime of some lakes (Tessema, 1998). In their study Ayenew and Legesse (2007), reviled that the level and volume of Lake Abiyata has been significantly reduced due to excessive pumping of water from the lake for soda extraction, and the utilization of water from feeder rivers and Lake Ziway for irrigation. The case of Lake Alemaya is a good example that signifies the magnitude of human impacts on water bodies. The multiple anthropogenic pressures particularly water abstraction put the lake on the verge of disappearance (Desta, et al. 2017). In contrast, lake Beseka has recently been growing in size as a result of increase in the net groundwater flux into the lake, related to the recent increment of recharge from the nearby irrigation fields and due to the rise of the Awash river (Ayenew, 2004; Ayenew, 2007). Over-irrigation has led salinization problem on irrigated farmlands, as saline groundwater table gradually raise and deposits salt on the surface. Salinization is a critical problem in the Awash valley and around Lake Ziway irrigation fields. The shallow ground water table of poor quality is expected to affect soil properties and crop yield. There are nearly 12 million ha of salt-affected soils in eastern and southern Ethiopia (Dinka, 2017; Tadesse, 2001).

3.4. Water pollution

Agriculture and urbanization are intensifying in Ethiopia, increasing pressure on the aquatic systems. The interaction between agricultural malpractices and the environment in Ethiopia results in relentless pollution of freshwater (Tadese 2001). For example, the water of Akaki and Kebena rivers flowing through Addis Ababa, the capital of Ethiopia as well as Lake Koka are heavily pollu- ted by industrial effluents containing chemicals and organic pollutants. Awash tributaries streaming from Addis Ababa are loaded with domestic sewage. Local people who have been relying on the lakes and rivers as source of water for drinking, animal watering, cleaning, fishing, traditional irri- gation practices, etc. have been severely impacted by the existing situations (Awoke, 2016; Akele, 2011).

3.5. Inadequate water storage capacity

During the rainy season, high rainfall intensity or prolonged rainfall, resulting in abundant water lost as runoff, flooding, and extremely high river water flow. Thus, water harvesting during the rainy season is indispensable for Ethiopia to irrigate crops in drier period of the year (Woube, 1999; Tadesse, 2001). If rains fail, or simply come too early or too late, the entire agricultural cycle can be disrupted, because there is inadequate water storage capacity to smooth and schedule water delivery (World Bank, 2006). Ethiopian water resources to bring meaningful development without reliable water control infrastructure is minimal (Awulachew, 2010). In recent years, efforts have been made to increase the water storage capacity by building several small earth dams and large water reservoirs. However, little emphasis was given for the sustainability of these water reservoirs by Ethiopian government. Most of the reservoirs have been suffering from excessive evaporation, seepage losses, serious sediment loads, siltation hazards and possible seismic activities. The reservoirs themselves have also become breeding sites for malaria mosquitoes and may aggravate other types of water-related diseases (Woube, 1999).

3.6. Weak institutional capacity

Lack of proper planning and misuse of water resources have brought environmental deterioration to many of Ethiopia's river basins (Woube, 1999). Inadequate attention has been given to the management of water resource both from an economic and an environmental perspective. In most case, there is limited water monitoring system or the data are not available to many potential users. Adoption of soil and water conservation measures has been very limited. Reasons for failed adoption by farmers are the poor extension approaches, lack of incorporating indigenous soil water conservation techniques, land tenure insecurity and the inability to make soil water conservation productive (Gebregziabher, et al. 2016; Tefera and Sterk, 2010). Institutional inefficiency in terms of cooperation and coordination among stakeholders has hindered efforts on the sustainable management of water resources.

4. Prospects of water management in Ethiopia

Despite all these challenges, soil and water conservation efforts are continuing in Ethiopia. The soil and water conservation work included water harvesting in drier regions, stream development, construction of earth dams, ponds, gully plugging, check dams, and others. The country has several large rivers that can irrigate arable lands, supplementing rainfed agriculture (Tadesse, 2001). Nonetheless, out of the total cultivable land, less than 40% of available land is currently under cultivation, and of the 3.7 million ha of irrigable land, only about 5% is irrigated. If Ethiopia has implemented successful irrigation system, agricultural development could contribute up to ETB 140 billion to the economy and potentially moving up to 6 million households into food security (Awelachew, et al.

2010). However, to capture the full potential, the country needs to address critical challenges in the planning, design, delivery, and maintenance of its irrigation systems.

5. Future directions

Land and water conservation is crucial to enhance the resilience of water and agricultural system. Appropriate watershed management practices and strategies should include reforestation, soil conservation and the promotion of water resource conservation. Minimize clearing forests for agricultural and energy use. In situ water harvesting techniques have proven to improve the efficient use of rainwater and increase the sustainability and reliability of rainfed agriculture by reducing runoff and evaporation (Grum et al. 2017). Moreover, incorporating soil organisms to agricultural fields enhance water infiltration and retention (Ismail, 2013; Lee et al. 2008). Hence, conservation of soil moisture in the agricultural fields using in situ water harvesting techniques should be practi- ced by farmers with the help of extension workers. An increased focus on groundwater should also be seen as a priority intervention to design effective and appropriate water resource management, as it is buffered from rainfall variability. In general, in order to alleviate current and future water management issues, well-planned and well-managed land and water resource development projects, implementation strategies that take into consideration the environmental and hydrological systems, effective climate change mitigation and adaptation strategies are vital. For long-term growth, investments should be geared towards projects which promote less water-dependent, more resilient, and livelihoods (World Bank, 2006).

6. Conclusions

Currently in Ethiopia, the sustainability of water and land resources is far from satisfactory. The country's environmental challenges involve complex cross-sectoral linkages. Lake of integrated water resources management and the land degradation–food insecurity–energy access–livelihood nexus are the key environment-development linkages identified by the World Bank's Country Environmental Analysis. Huge investment in water resources infrastructure and institutions is ne- eded to achieve water security. However, Ethiopia cannot fully mitigate the impact of hydrological variability through water infrastructure and management investments alone. Therefore, interventions aimed at managing hydrological variability and interventions aimed at decreasing the vulnerability of the economy to these shocks are crucial. These interventions include integrated watershed mana- gement, programs to improve livelihood, and investment in hydraulic infrastructure that serves multiple needs, i.e. hydropower production, irrigation systems, and storage adequate to mitigate both drought and floods.

Acknowledgements

This work was supported by Stipendium Hungaricum scholarship program (T049120/F169207)

References

Akele, T.: 2011. The practice and challenges of lake management in Ethiopia-the case of lake Koka.

Awoke, A. Beyene, A., Kloos, H., Goethals, P.L., and Triest, L.: 2016. River water pollution status and water policy scenario in Ethiopia: raising awareness for better implementation in developing countries. Environmental management. 58. 4: 694–706.

Awulachew, S.B., Erkossa, T. and Namara, R.E.,: 2010. Irrigation potential in Ethiopia: Constraints and opportunities for enhancing the system. Unpublished Report to the Bill and Melinda Gates Foundation.

Awulachew, S.B., Yilma, A.D., Loulseged, M., Loiskandl, W., Ayana, M. and Alamirew, T.: 2007. Water resources and irrigation development in Ethiopia, 123. Iwmi.

Ayenew, T. and Legesse, D.: 2007. The changing face of the Ethiopian rift lakes and their environs: call of the time. Lakes & Reservoirs: Research & Management. 12. 3: 1491–65.

Ayenew, T.: 2004. Environmental implications of changes in the levels of lakes in the Ethiopian Rift since 1970. Regional environmental change. 4. 4: 192–204.

Ayenew, T.: 2007. Water management problems in the Ethiopian rift: Challenges for development. Journal of African Earth Sciences. 48. 2: 222-236.

Berhane, G., Gebreyohannes, T., Martens, K. and Walraevens, K.: 2016. Overview of micro-dam reservoirs (MDR) in Tigray (northern Ethiopia): Challenges and benefits. Journal of African Earth Sciences. 123. 210–222.

Chukalla, A.D., Haile, A.M. and Schultz, B.: 2013. Optimum irrigation and pond operation to move away from exclusively rainfed agriculture: the Boru Dodota Spate Irrigation Scheme, Ethiopia. Irrigation science. 31. 5: 1091–1102.

Desta, H. and Lemma, B.: 2017. SWAT based hydrological assessment and characterization of Lake Ziway sub-watersheds, Ethiopia. Journal of Hydrology: Regional Studies. 13.122–137.

Devi, R., Tesfahune, E., Legesse, W., Deboch, B. and Beyene, A.: 2008. Assessment of siltationand nutrient enrichment of Gilgel Gibe dam, Southwest Ethiopia. Bioresource Technology. 99. 5: 975–979.

Dinka, M.O.: 2017. Lake Basaka Expansion: Challenges for the Sustainability of the Matahara Irrigation Scheme, Awash River Basin (Ethiopia). Irrigation and Drainage. 66. 3: 305-315.

Gebregziabher, G., Rebelo, L.M. and Langan, S.: 2016. Interdependence in rainwater management technologies: an analysis of rainwater management adoption in the Blue Nile Basin. Environment, development and sustainability. 18. 2: 449–466.

Grum, B., Assefa, D., Hessel, R., Woldearegay, K., Ritsema, C.J., Aregawi, B. and Geissen, V.: 2017. Improving on-site water availability by combining in-situ water harvesting techniques in semi-arid Northern Ethiopia. Agricultural Water Management. 193. 153-162.

Hishe, S., Lyimo, J. and Bewket, W.: 2017. Soil and water conservation effects on soil properties in the Middle Silluh Valley, northern Ethiopia. International Soil and Water Conservation Research. 5. 3: 231–240.

Ismail, S.M.: 2013. Influence of effective microorganisms and green manure on soil properties and productivity of pearl millet and alfalfa grown on sandy loam in Saudi Arabia. African Journal of Microbiology Research. 7. 5: 375–382.

Korecha, D. and Barnston, A.G.: 2007. predictability of June–September rainfall in Ethiopia. Monthly weather review. 135. 2: 628–650.

Lee, C.T., Ismail, M.N., Razali, F., Muhamad, I.I., Sarmidi, M.R. and Khamis, A.K.: 2008. Application of effective microorganisms on soil and maize. Journal of Chemical and Natural Resources Engineering, Special Edition,1-13.

MoWR (Ministry of Water Resources).: 1996. “Omo- Gibe Basin Integrated Development Master Plan Study,” Final Report, Executive Summary, Addis Ababa.

Nyenje, P.M., Foppen, J.W., Uhlenbrook, S., Kulabako, R. and Muwanga, A.: 2010. Eutrophication and nutrient release in urban areas of sub-Saharan Africa—a review. Science of the Total Environment. 408. 3: 447–455.

Schmidt, E. and Zemadim, B.: 2015. Expanding sustainable land management in Ethiopia: Scenarios for improved agricultural water management in the Blue Nile. Agricultural Water Management. 158. 166–178.

Taddese, G.: 2001. Land degradation: a challenge to Ethiopia. Environmental managemen. 27. 6: 815–824.

Tefera, B. and Sterk, G.: 2010. Land management, erosion problems and soil and water conservation in Fincha’a watershed, western Ethiopia. Land Use Policy. 27. 4: 1027–1037.

Tessema, Z.: 1998. Hydrochemical and water balance approach in the study of high water level rise of Lake Beseka. Unpublished M. Sc thesis, University of Birmingham, UK, 90.

World Bank,: 2006: Ethiopia: Managing Water Resources to Maximize Sustainable Growth. A World Bank Water Resources Assistance Strategy for Ethiopia. Agriculture and Rural Deve- lopment Department, Washington, DC.

Woube, M.: 1999. Flooding and sustainable land–water management in the lower Baro–Akobo river basin, Ethiopia. Applied Geography. 19.3: 235–251.

Woube, M.: 1999. Flooding and sustainable land–water management in the lower Baro–Akobo river basin, Ethiopia. Applied Geography. 19. 3: 235–251.

Zinabu, G.M.: 2002. The Ethiopian Rift Valley lakes: Major threats and strategies for conservation. Ethiopian Rift Valley Lakes. Backhuys, Leiden, 259–271.

The challenges and prospects of water resource management in Ethiopia

Abstract

Water has always played a central role in Ethiopian society, as rainfed agriculture accounts for 90 % of the export, 85 % of employment and 47% of the GDP. In spite of being relatively rich in wa- ter and land resources, Ethiopia is unable to produce reliable food supply. Extensive land degra- dation and deforestation coupled with erratic water distribution both in space and time are the major causes of the problem. On top of that, the current frequent dry spells and droughts exacerbate the already impoverished water condition of the country. The Ethiopian government has recognized water as major component in the economic development and poverty reduction. Accordingly, ef- forts and investments have been done in Ethiopia to increase the irrigated area, on community-based soil and water conservation practices, and hydropower developments. Despite these efforts, the sustainability of water and land resources is far from satisfactory. The major reasons jeopardizing the sustainability are poor agronomic and water management practices, failure of local institutions to sustainably manage water resources, inadequate water storage capacity, and poor water monitor- ing system. To enhance the resilience of water and agricultural system, Ethiopia needs well-planned and well-managed land and water resource development projects, implementation strategies that take into consideration the environmental and hydrological systems, well-coordinated water moni- toring scheme, and effective climate change mitigation and adaptation strategies. This paper asses- ses the challenges and prospects of water resource management, and forward future directions for the sustainable water resource management in Ethiopia

Keywords: Ethiopia, Water management, Land degradation, Soil erosion

THE ROLE OF SOIL ORGANIC MATTER IN SOIL MOISTURE REGIME

Tóth József Attila

Szent István Egyetem, Gödöllő, 2100, Páter Károly u. 1., tothjozsefa91@gmail.com

Introduction

Soil biological life and activity depends on moisture, thus biomass production increases with elevated precipitation (Bot et al., 2005). Soil water retention has a strong effect on soil biology and many soil properties. In accordance to increasing the soil physical properties regarding moisture uptake and holding capacity, the best way is to increase the soil organic matter contect of soils through best-fitting agricultural practice.Increased soil organic matter enhances water retention and infilt- ration, reduces soil bulk density, at least initially (Franzluebbers, 2002).

Literature review

Organic matter defines some of the physical and chemical properties of the soil. At lower matric potential, soil organic matter increases water adsorbing capacity (Yang et al., 2014). Although it is affected by texture, water retentionshows a significant higher amount in soils with high organic matter content (Rawls et al., 2003). Especially with coarse texture – the correlation between water retention and soil organic matter content is higher, compared to fine-textured soils. In order to mi- nimize the duration and impact of a future drought, the water uptake and holding capacity of the soil needs to be maximalized. Soil moisture management can be improved by three basic practices: (1) by increasing water infiltration, (2) by increasing soil moisture storage capacities, and (3) by ma- naging soil evaporation (Bot et al., 2005).

Higher rates of water infiltration and aggregate stability were measured under limited tillage systems, compared to plow tillage, alongside with water content during critical periods (Alvarez & Steinbach, 2009). Going by these results, water uptake speed and water holding capacity can be increased by choosing conserving tillage methods. With the addition of long-term studies, which show that results of no-till management is limited in means of improving hydraulis properties of the soil (Blanco-Canqui et al., 2017).

Conservation tillage preserves soil moisture and increases the soil organic matter content of the soils, improving soil conditions during arid periods (Bescansa et al., 2006). At higher matric poten- tial, no-till and reservoir tillage also alters bulk density (Yang et al, 2014). This means the remai- ning moisture in the soil increases. Alongside with increasing water content in the soil, biological activity is enhanced, which process speeds up carbon sequestration and complex organic carbon fixation. No-till also helps water retention in the top 10 cm layer of the soil, as well as increasing the soil organic matter (Yemai et al, 2012).Since long-term results show that no-till soils do not differ in physical properties on the long run, increasing porosity by means of tillage could be a solution for compaction and other negative effects caused by no-till.Also, clay particles which are complexed with organic carbon are more resistant to water dispersion (Dexter et al., 2008).

Summary

Soil organic matter is the key element to enhance water management in the soil (Franzluebbers, 2002).In order to prepare our arable soils to the severing climatic challenges and also to speed up carbon sequestration, it is vital to increase and conserve the organic matter content. The most effective way to increase soil organic matter is by agricultural methods: adaptive tillage methods and preservative water management during practice.

Keywords: Soil Organic Matter, Water Regime

Acknowledgements

I would like to thanks to my supervisor, Csákiné Dr. Michéli Erika, alongside with the Department of Soil Science and Agrochemistry.

References

Alvarez R., Steinbach H.S. (2009): A review of the effects of tillage systems on some soil physical properties, water content, nitrate availability and crops yield in the Argentine Pampas. Soil & Tillage Research 104: 1-15.

Bescanca P., Imaz M. J., Virto I., Enrique A., Hoogmoed W. B. (2006): Soil water retention as affected by tillage and residue management in semiarid Spain. Soil & Tillage Research 87: 19-27.

Blanco-Canqui H., Wienhold B. J., Jin V. L., Schmer M. R., Kibet L. C. (2017): Long-term tillage impact on soil hydraulic properties. Soil & Tillage Research 170: 38-42.

Bot A., Benites J. (2005): The importance of Soil Organic Matter: Key to Drought-resistant Soil and

Dexter A. R., Richard G., Arrouays D., Czyz E. A., Jolivet C., Duval O. (2008): Complexed organic matter controls soil physical properties. Geoderma 144: 620-627.

Franzluebbers A. J. (2002): Water infiltration and soil structure related to organic matter and its stratification with depth. Soil & Tillage Research 66: 197-205.

Jemai I., Aissa N. B., Guirat S. B., Ben-Hammouda M., Gallali T. (2012): Impact of three and seven years of no-tillage ont he soil water storage, in the plant root zone, under a dry subhumid Tunisian climate. Soil @ Tillage Research 126: 26-33.

Rawls W. J., Pachepsky Y. A., Ritchie J. C., Sobeck T. M., Bloodworth H. (2003): Effect of soil organic carbon on soil water retention. Geoderma 116: 61-76.

Yang F., Zhang J-L., Li D-C., Zhao Y-G., Liu F., Yang R-M., Yang F. (2014): Organic matter controls of soil water retention in an alpine grassland and its singificance for hydrological processes. Journal of Hydrology 519: 3086-3093.

IRRIGATION WATER REQURIEMENTS OF RICE IN MYANMAR

Wai Yan Aung[1], Waltner István[2]and Vekerdy Zoltán[3]

1Szent István Universitywaiyanaung.mr@gmail.com
2Szent István Universitywaltner.istvan@mkk.szie.hu
3Szent István Universityvekerdy.zoltan@mkk.szie.hu and University of Twente z.vekerdy@utwente.nl

Abstract

Rice is the staple food not only in Asia but also in part of the Pacific under semiarid climate where water resource management is critical for the resource use sustainability. Agriculture in Myanmar, dominated by paddy rice cultivation, generates a direct or indirect economic livelihood for over 75% of the population. Rice is grown throughout the country by resource poor rural farmers and landless agricultural laborers on small farms averaging only 2.3 ha in size. However, very limited data exists on rice water use and irrigation water requirement in this water-scarce environment un- der climate change conditions. Understanding crop water requirements is essential for better irriga- tion practices, scheduling and efficient use of water. The objectives of this study were to determine crop evapotranspiration, yield and biomass values of rice; and to evaluate the performance of appli- cation of the AquaCrop model for rice fordifferent irrigation water management practices. Field experiment datawas collected during the 2016 hot and dry season. Results indicated that crop eva- potranspiration (ETc) varied from 0.5 to 6.6 mm with the highest ET obtained during the growing seasons. Irrigation water requirement varied from 340 to 400 mm in the summer season. Rice grain yield was a function of the growing season and the applied effective irrigation scheduleand varied from 4.9 to 5.66 t ha^{-1}. Rice water use efficiency related to ETa and irrigation both had positive correlation relationship with rice grain yield.The results of this study can be used as a guideline for rice irrigation water requirement for the irrigation design projects, advisers, universities, producers, and other operators in Myanmar.

Introduction

Climate change is now one of the problems of human society and the hazard to the environment is considerable. Earth temperature is rising,and changes in rainfall and temperature both intime and place occur, causing even human losses. It is understandable, that climate change got into the focus of research efforts. Global warming issignificant as was proved by the temperature time series throughout the world (Gilanipour & Gholizadeh, 2016). Global warming has caused significant influence in Myanmar for agricultural and food security. Rice is the staple food of not only in Asia but also in part of the Pacific. The Asia-Pacific Region produced over 90 percent of world rice pro- duction and consumption. Agriculture in Myanmar, dominated by paddy rice cultivation, generates a direct or indirect economic livelihood for over 75% of the population. Rice is grown throughout the country by resource poor rural farmers and landless agricultural laborers on small farms averag- ing only 2.3 ha in size.Myanmar's agriculture is heavily dependent on the monsoon rains. Even some areas suffer from too much rain, others too little. Government efforts in the 1990s increased the amount of irrigated land to 2.2 million acres.

FAO developed the AquaCrop model (Steduto, Hsiao, Fereres, & Raes, 2012) to address food secu- rity and to assess the effect of environment and management on crop production which integrates data on climate, crop and soil to assess reference evapotranspiration (ET_0), crop evapotranspiration (ETc) and irrigation water requirements.

Research Objectives

Our study aims

- to determine crop evapotranspiration, yield and biomass values of rice(*Oryza sativa* L.);
- to evaluate the performance of application of the AquaCrop model for rice underdifferent irrigation water management practices.

Basic terms

Estimation of crop water requirement

Evapotranspiration is one of the most important key components of hydrological cycle and the major source of water lossfrom the surface. Therefore, it is an important parameter for climatological and hydrological studies, as well as for agricultural water resources management. Calculation of it is based on the surface energy balance. Combining the actual evapotranspiration (ETa) with pecipitation and sufrace runoff in the water balance allows us to estimate the available soil moisture in the root zone, for example, on a daily basis. Soil moisture above the wilting point is readily available for the crop. This soilwater content is estimated from soil, crop and rooting characteristics and from the ET_0 rate. Depletion of soilwater content approaching the permanent wilting point results in a proportional reduction of ETa. (Allen, Pereira, Raes, & Smith, 1998). Detailed procedures are available to assess the impact of stress on reduced evapotranspiration based on the water balance calculations with parameters of critical soil water content values and rooting depth.

AquaCrop

The AquaCrop model was developed by the Land and Water Division of FAO(Steduto et al., 2012; Steduto, Hsiao, Raes, & Fereres, 2009).Itis a water-driven model for the purpose of decision support in scenario analysis and also to use as a tool for planning. AquaCrop model relates its crop-soil-atmosphere components through its water balance (Toumi et al., 2016). The AquaCrop model uses input files for simulation: climate file (minimum and maximum air temperature, wind speed, relative humidity, ET_0, rainfall and CO_2), crop file (day number after transplanting, time to emergence, maximum canopy cover, time to flowering, start of senescence, and maturity), soil file, management file andirrigation file. It doesnot use leaf area index (LAI) but it uses canopy cover (CC) as the basis to calculate plant transpiration (Tr) and soil evaporation (E). Tr is related to CC which is proportional to the extent of soil cover whereas evaporation is proportional to the area of soil uncovered (1-CC) (Toumi et al., 2016).

Determination of irrigation practices by using the AquaCrop model is one possible irrigation water management strategy that may help farmers to apply limited amounts of water to their crops in time and amount vital for optimum crop water productivity. In order to allocate the scarce water resources among competing uses and to schedule irrigation water, the level of water deficit which maximizes crop water productivity has to be identified. This level of water deficit varies with crop type and cropping pattern, soil type, depth and fertility, climate, water quality as well as type of irrigation system. In addition market accessibility and availability of land and water policy are some of the external factors that may affect crop water productivity.

Materials and Methods

Site description

The study was conducted at Yezin in Myanmar, during the summer seasonof 2016. The experi- mental site is located on theresearch station of the Department of Agricultural Research at Yezin (19°50'12.6"N 96°16'32.9"E) at above 122 m sea level. Climate at site is typically tropical, 8-month dry period followed by a short wet season, and characterized by large annual amplitudes in temperature. Between February and May, solar radiation and maximum temperatures are high. The climate of the experimental site is tropical with a short rainy season from July to October. Typically, rice production takes place twice a year, from February to June in the summer season, and from August to November in the wet season.

Fig. 1: Yezin Area

Climate Data

The most imporant climatic factors affecting evapotranspiration are radiation, air temperature, humidity and wind speed. The reference crop evapotranspiration (ET_0) expresse the evaporative power of the atmosphere. The reference crop evapotranspiration represents the evapotranspiration from a standardized vegetated surface of a specific crop. The weather data required by AquaCrop model are daily values of minimum and maximum air temperature, reference crop evapotranspiration, rainfall and mean annual carbon dioxide concentration (CO_2). ET_0 was estimated using the daily maximum and minimum temperature, wind speed at 2 m above ground surface, and mean relative humidity (RH). Weather data were collected at Yezin weather station.

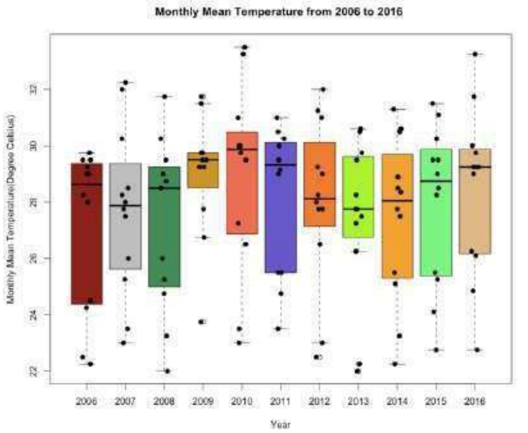


Figure 2. Monthly mean temperatures from 2006 to 2016 of theYezin Area. During ten years, 2013 has the lowest mean temperature and 2010 is highest mean temperature.

Crop data and Soil Data

In the study area, rice, maize, green gram, etc. are the major cultivated crops. We focus on rice in this study,due tothe importance of rice production in this region. Crop coefficient values (Kc) are taken from available published data. Kc values for initial, mid and late growth stages of rice are used for the dry season months. Resistance to transpiration, crop height, crop roughness, reflection, ground cover and crop rooting characteristics result in different ET levels ofdifferent types of crops under identical environmental conditions.

AquaCrop simulates soil water balance as a percentage of TAW. Depending on the soil horizon, soil water content at saturation ranged from 33 to 35%, at field capacity from 18 to 23 % and at wilting point from 11 to 16%. Bulk density varied from 1.2 g/cm^3 and saturated conductivity was about 1.200 mm/day.

Result and Discussions

Calibration of the AquaCrop model

Various parameters affecting CC, actual ETc, biomass and gross yieldhave been calibrated. The values of growing degree days(GDD) in each crop development stages from day after planting were adjusted using the data collected from field during the cropping season. GDD varied for the different stages where the R value of both parameters is 0.86, due to the differentclimaticconditions.

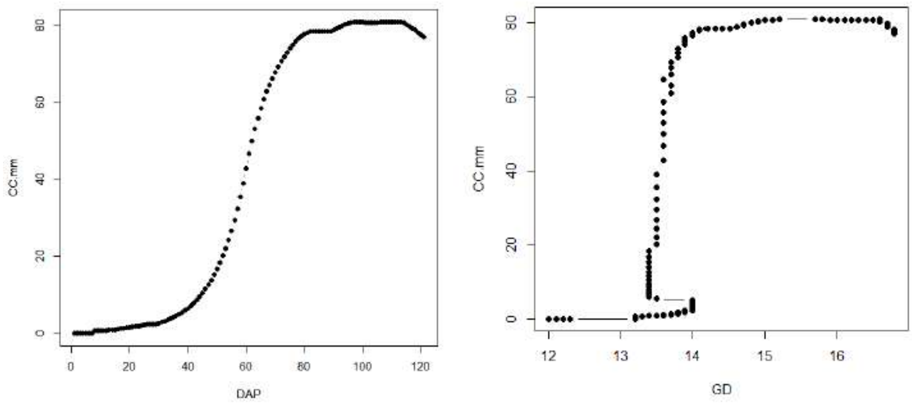


Fig. 3. The simulated canopy cover (CC) for the calibration field cropping season.
Line graphs indicate the differences in mean between DAP and CC , GDD and CC.

The modelled field was sown on 23 February where the air temperature is different to the base temperature at the early stages of planting. In the mid-season of the growing period the temperature is higher.In March, April and May the air temperature is near to the highest values, and resultingin high values of GDD.

Rice evapotranspiration (ET)

Various parameters are used to define the relationship between water and crop yield; these are ET, available water, and amount of irrigation. ET has a physiological relationship with the yield. Available water is less than the sum of irrigation and precipitation due tolosses.Irrigation compensatesthe effect of the lack of rainfall on the yield. During the dry season from February to June, ETa in- creased with crop growth, reached its maximum during rice mid-season and decreased during the maturity phase. The simulation of actual evapotranspiration (ETa) was based principally on two parameters: maximum evaporation (Ex) and the crop transpiration coefficient($K_{cTr,x}$). The calibrated values of Ex and $K_{cTr,x}$ were 0.563 and 2.79, respectively. The value 0.563 of Ex was determined based on the observed frequency of water supply and the average value of ET_0(4 mm/day) during the growing season. For $K_{cTr,x}$, whenCC was less than 95%, AquaCrop model adjusted the value of $K_{cTr,x}$ based on CC in order to obtain the actual value of plant transpiration (Tr) which is about 2.74(Toumi et al., 2016). Fig. 4 displays the time seriesof simulated ETaat differenctCC values by the AquaCrop model for fields during the cropping season.

Yield response to irrigation water requirement

A direct relation exists, therefore, between biomass production and water consumed through transpiration. Water stress and reduced transpiration result in a reduced biomass production that normally also reduces yields.The total irrigation was estimated at 400 mm for the evaluated schedule, 400 mm for the first update and 340 mm for the second update of the irrigation schedule for grow- ing season.The relationship between available water and yield is strong. Even when theamount of available water approaches adequacy, losses occur due to the non-uniformity and imprecision of the system and soil inhomogeneity.

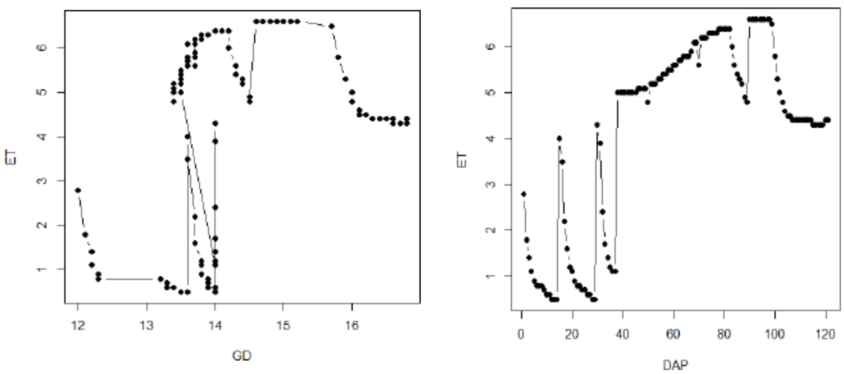


Fig 4. Differences of rice actual evapotranspiration (ETc act) between GDD and DAP during four growing seasons by AquaCrop

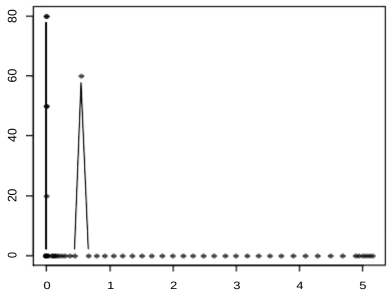
Parameters	Evaluated schedule	1st update	2nd update
Biomass (t/ha)	9.423	10.6	9.7
Dry yield (t/ha)	4.9	5.66	5.15
Irrigation(mm)	400	400	340
Water Productivity (ET)	0.95	1.08	1.02
Harvest Index (%)	52.0	53.5	53.1
Amount of irrigated water (mm)	60 60 60 80 80 60	50 50 60 20 80 80 60	50 50 20 80 80 60

Table 1. Biomass, dry yield, irrigation, water productivity (ET) and harvest index of rice under different irrigation schedule of growing season.

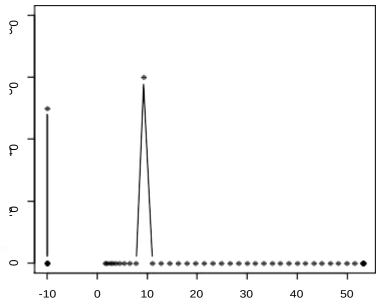
Conclusion

Rice grain yield varied from 4.9 to 5.66 t ha^{-1}, adjusted irrigation schedule, and showed seasonal variability with slightly higher during the summer season. Evapotranspiration (ET) varied from 0.5 to 6.6 mm with the highest ET obtained during the growing seasons from day after transplanting. Irrigation water requirement varied from 340 to 400 mm in summer season. Rice water use efficiency related to ETa and irrigation both had positive correlaion relationship with rice grain yield. The combination of all parameters under study in this research revealed that the amount of irrigated water 340 mm ha^{-1} was the most effective and is recommended as the optimum irrigation schedule for rice within summer season in Yezin, Myanmar.

Irrigation (mm)



Irrigation (mm)



Yield (t/ha) Harvest Index

Yield

Summary

Based on this study, it canbe recommended that the seasonal irrigation should be of 340 mm to get yield of 5.15 t ha^{-1} and 400 mm for seven adjusted times to get yeald of5.66 t ha^{-1}.If the same amount of irrigation water is applied for only six times, the yield decreases from 5.66 to 4.9 t ha^{-1} for the summer rice growing season, at Yezin, Myanmar. The results of this study can be used as a guideline for rice water use and irrigation water requirement by the irrigation designers, agricultural project managers in Myanmar.

Key words- AquaCrop;Rice;Evapotranspiration; Irrigation ;Yezin;Canopy cover,DAR-Department of Agricultural Research

Acknowledgement

The authors wish to acknowledge the Food and Agricultural Organization of the United Nations for providing the financial assistance for undertaking the experiment at Yezin, DAR in Myanmar.

References

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*. Rome: Food and Agriculture Organization of the United Nations.

Gilanipour, J., & Gholizadeh, B. (2016). Prediction of Rice Water Requirement Using FAO-CROPWAT Model in North Iran under Future Climate Change. *Preprints*, (October), 1–9. http://doi.org/10.20944/preprints201610.0134.v1

Steduto, P., Hsiao, T. C., Fereres, E., & Raes, D. (2012). *Crop yield response to water*. *Fao Irrigation and Drainage Paper Issn*. Retrieved from www.fao.org

Steduto, P., Hsiao, T. C., Raes, D., & Fereres, E. (2009). Aquacrop-the FAO crop model to simulate yield response to water: I. concepts and underlying principles. *Agronomy Journal*, *101*(3), 426–437. http://doi.org/10.2134/agronj2008.0139s

Toumi, J., Er-Raki, S., Ezzahar, J., Khabba, S., Jarlan, L., & Chehbouni, A. (2016). Performance assessment of AquaCrop model for estimating evapotranspiration, soil water content and grain yield of winter wheat in Tensift Al Haouz (Morocco): Application to irrigation management. *Agricultural Water Management*, *163*, 219–235. http://doi.org/10.1016/j.agwat.2015.09.007

A Szent István Egyetem, mint az**EFOP-3.6.1-16-2016-00016**számú,SZIE Szarvasi Campusának kutatási és képzési profiljának specializálása intelligens szakosodással: mezőgazdasági vízgazdálkodás, hidrokultúrás növénytermesztés, alternatív szántóföldi növénytermesztés, ehhez kapcsolódó precíziós gépkezelés fejlesztése című EU projekt keretében megrendezésre kerülő konferencia.

Nyomda:

Digitális Kalamáris Kiadó és Gyorsnyomda

5540 Szarvas, Fűzfa u. 27.