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RESEARCH ARTICLE

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## QUALITY ASSESSMENT OF WASTEWATER TREATMENT PLANT EFFLUENT AND IRRIGATION APTITUDE

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### ABSTRACT

The aim of the present study was to assess the irrigation aptitude of treated effluent from a wastewater treatment plant in Korhogo, a city located in the north of Côte d'Ivoire. Physicochemical characteristics of the treated effluent collected over seven weeks were determined and agronomic quality parameters were calculated (SAR, %Na, KR...). Projection of the chemical elements on Piper diagram showed that the hydrofacies of the treated effluent was of chloride – sulfate, calcium – magnesium type. Agronomic water quality parameters indicated that the treated effluent ranged from good to acceptable, inducing a low risk for soil salinization and alkalinization. One water class was identified: class C3S1, characteristic of water generally suitable for irrigation of crops moderately tolerant to salts, on well-drained or well-permeable soils.

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## INTRODUCTION

Water is essential for life and involved in almost all human activities, including domestic, agricultural, commercial and industrial. Agriculture is one of the largest users of water in the world, accounting about 70% (>95% in some countries) of all extractions of water worldwide (WHO, 2013; Gleick, 2000; FAO, 2002). Usually, water used in agriculture is withdrawn from surface water and groundwater. It is mainly used for irrigation and to compensate periods of drought. In recent years, water availability has become a major worldwide concern due to rapid population growth, urbanization, extensive agriculture, industrialization and climate change (Smith *et al.*, 2018). In many places around the world, water demand for agriculture already exceeds available supply, compromising food security and leading to conflicts over water access. It is therefore crucial to explore alternative solutions to meet the growing agricultural water demand. Reusing wastewater (untreated or treated) for irrigation is an interesting solution for sustainable agriculture (Scott *et al.*, 2018). Indeed, reusing wastewater can help to reduce pressure on traditional water resources (surface water and groundwater). Wastewaters, particularly domestic ones, are widely available throughout the year, regardless of the season. They can be reused for irrigation if they meet certain quality criteria, such as microbiological and physicochemical standards. Microbiological criteria refer to the absence of bacteria responsible of fecal contamination, such as Enterococci, E. coli, and coliforms, to

protect people handling the wastewater (e.g. agricultural workers), and to ensure safe agricultural products. Physicochemical quality criteria mainly concern suspended solids (SS), nutrients (nitrogen, phosphorus and potassium), salinity, etc. SS can obstruct irrigation equipment, nutrients can influence soil fertility, while salinity can affect soil and crop growth. Reusing wastewater for irrigation requires rigorous assessment of its aptitude to ensure the safety of produced foods and to prevent adverse effects on soils and ecosystems (Wang *et al.*, 2019). The quality of irrigation water can affect crop growth, soil productivity and the environment. Several cases of salinization of irrigated soils have been reported around the world (Rouabia and Djabri, 2010). At least 3 hectares of arable lands are lost every minute around the world due to salinization of irrigated soils (Borena and Hassen, 2022; Buringh, 1977). This situation has become a major concern for food security in many countries, particularly in developing countries, such as those in Africa. When water used for irrigation has high sodium (salt) and low calcium content, the exchangeable ion complex (soil adsorbent complex) may become supersaturated with sodium, thereby degrading soil structure (Todd and Mays, 2004). Furthermore, when irrigation water has low salt content and electrical conductivity below 200  $\mu\text{S}/\text{cm}$ , it tends to rapidly mobilize calcium from the soil. This can lead to clogging of pore spaces and reduce soil permeability (Ayers and Westcot, 1994). It is therefore crucial to assess water quality and its irrigation aptitude to prevent risks of soil degradation and contamination of agricultural products. The objective of the present study was to determine the physicochemical quality of treated wastewater from a wastewater

treatment plant (WWTP) located in the city of Korhogo (Côte d'Ivoire) and then assess its irrigation aptitude.

## MATERIAL AND METHODS

**Study area:** Study was conducted in Korhogo, a city located in the north of Côte d'Ivoire (West Africa) ( $5^{\circ}16' - 6^{\circ}16' \text{ W}$ ,  $8^{\circ}32' - 10^{\circ}20' \text{ N}$ ), at about 635 km from Abidjan and 356 km from Yamoussoukro (political capital) (Figure 1). Climate in Korhogo is Sudanese, characterized by two distinct seasons: dry season from December to April and wet season from May to October. Temperature in Korhogo varies between  $16^{\circ}$  and  $36^{\circ}\text{C}$ . The hottest months in the year are February, March and April, with  $36^{\circ}\text{C}$  and the coldest months are December and January, with  $16^{\circ}\text{C}$ . The average monthly humidity in Korhogo is 20% and the annual rainfall varies between 1.100 mm and 1.600 mm. Korhogo is the fourth largest city in Côte d'Ivoire in terms of population and economy, covering an area of about 12640.4 km<sup>2</sup>.

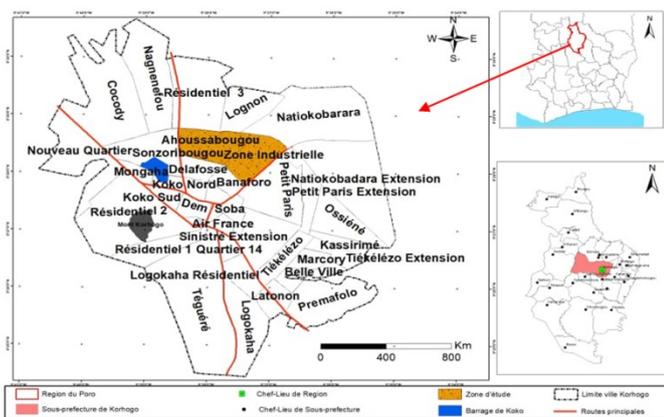


Fig. 1. Location of the study area

**Sampling:** Treated effluent was collected at the outlet of the WWTP of the city of Korhogo, which receives fecal sludge from septic tanks around the city. The WWTP consists of two treatment lines, each including the following steps: screening – one primary settling tank – drying beds – one anaerobic pond – one facultative aerobic pond. The total treatment capacity of the WWTP is 100 m<sup>3</sup>/d. Sampling was carried out weekly over a period of 7 weeks, from May to June. About 5 L of sample was collected each time in a plastic bottle and stored at 4 °C until analysis. pH, temperature and conductivity were analysed immediately on-site, while other parameters were analysed in the laboratory.

### Analytical methods

**Temperature, pH and conductivity measurements:** Temperature, pH and conductivity were measured immediately on-site after sampling using a HANNA multi-parameter (H19828).

**Analysis of cations:** Calcium and magnesium ions were analysed using a complexometric titration method with an analytical instrument HANA (H98164). Titration was performed with a solution of disodium ethylene diamine tetra acetic acid, using Erichrome Black T as an indicator. It produces dark red or purple color in the presence of calcium and magnesium ions. Sodium and potassium ions were analysed using BWB-XP flame emission photometer.

**Analysis of anions:** Nitrates ions were analyzed using a HACH spectrophotometer (DR1900) according to Hach Method 8039 (Nitrovers 5, Method). Sulfate ions were analyzed using a HACH spectrophotometer (DR1900) according to Hach Method 8051 (SulfaVer 4, Method). Phosphorus (as PO<sub>4</sub><sup>3-</sup>) was analyzed using the same spectrophotometer and Hach Method 8048 (PhosVer 3 ®,

Ascorbic Acid) Method). Carbonate ions were determined by titrimetric method measuring alkalimetric titre (AT) and complete alkalimetric titre (CAT) (MA. 315 – Alc-Aci 1.0) (CEAEQ, 2016). Chloride ions were analysed by titration with a standardized 0,1 N silver nitrate solution in presence of potassium chromate and nitric acid. The endpoint was indicated by the appearance of red silver chromate color persisting for 1 to 3 minutes (MA. 300 – Ions 1.3) (CEAEQ, 2020a).

**Water hardness and total dissolved solids:** Water hardness was analysed by titration using EDTA (0,01 mol/L) and Eriochrome T black (EBT, 0,5%) as colored indicator (MA. 200 – Mét. 1.2) (CEAEQ, 2020b), expressed in meq/L or °f. Total dissolved solids (TDS) were determined ~~out~~ by a gravimetric method by filtering sample, evaporating the filtrate, and drying and weighting the residue (MA. 115 – S.D. 1.0) (CEAEQ, 2023).

### Determination of the agronomic water quality indices

**Sodium adsorption rate:** Sodium absorption rate (SAR) expresses the risk of alkalization and is calculated as the excess of sodium relative to calcium and magnesium by equation 1 (Richards, 1954):

$$\text{Eq. 1. SAR} = \frac{\text{Na}^+}{\sqrt{\frac{\text{Ca}^{2+} + \text{Mg}^{2+}}{2}}}$$

Where Na<sup>+</sup>, Ca<sup>2+</sup>, and Mg<sup>2+</sup> (in meq/L) is the concentration of sodium, calcium, and magnesium, respectively.

**Percentage of sodium:** The percentage of sodium (Na%) is an important parameter for the classification of water samples for irrigation. It is calculated by equation 2 (Wilcox, 1955):

$$\text{Eq. 2. \%Na} = \frac{\text{Na}^+}{\text{Na}^+ + \text{K}^+ + \text{Mg}^{2+} + \text{Ca}^{2+}} * 100$$

Where, Na<sup>+</sup>, Ca<sup>2+</sup>, K<sup>+</sup>, Mg<sup>2+</sup> represents the concentration (in meq/L) of sodium, calcium, potassium and magnesium, respectively.

**Kelly ratio:** Kelly ratio (KR) or Kelly coefficient represents the ratio of sodium to magnesium and calcium ions. KR is calculated by equation 3 (Kelly, 1963):

$$\text{Eq. 3. KR} = \frac{\text{Na}^+}{\text{Ca}^{2+} + \text{Mg}^{2+}}$$

Where, Na<sup>+</sup>, Ca<sup>2+</sup> and Mg<sup>2+</sup> represents sodium, calcium and magnesium ions concentration, respectively.

### Characteristic diagrams

Two characteristic diagrams were used to assess irrigation aptitude:

- ❖ **Diagram 1:** SAR vs. electrical conductivity (indicating soil salinity and risk of alkalization)
- ❖ **Diagram 2:** Sodium percentage vs. electrical conductivity (indicating exchangeable sodium percentage in soils).

## RESULTS AND DISCUSSION

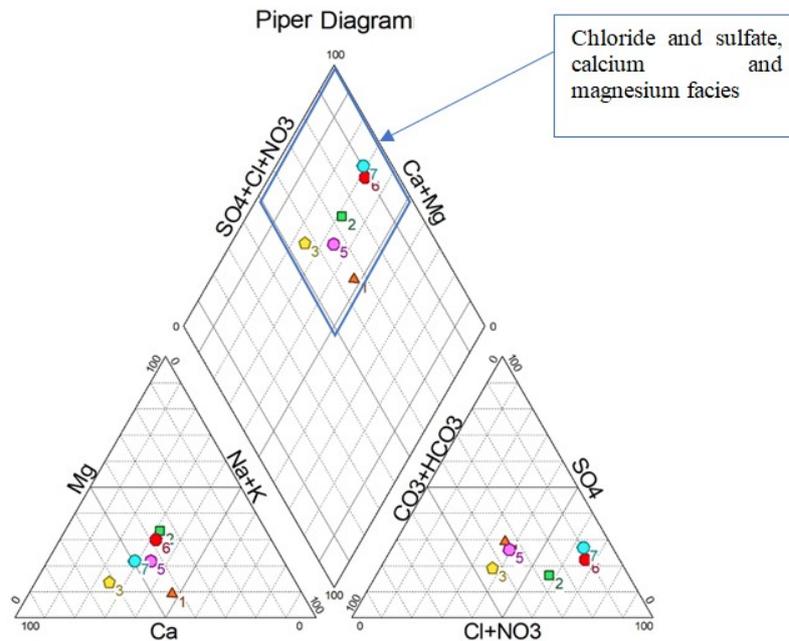
**Physicochemical composition of the treated effluent:** The physicochemical composition of the treated effluent from the WWTP of Korhogo is summarized in table 1. Analysis shows that temperature of the effluent varied from 25.0°C to 26.1°C, with an average value of 25.6°C. The temperature of water was linked to the ambient temperature in Korhogo. The pH of the effluent varied from 6.3 to 9.5, with an average value of 8.2. It complied with WHO recommended standards for wastewater discharge and reuse for irrigation (WHO, 2013). However, long-term use of the treated

effluent must be conducted under pH control, since uncontrolled irrigation may cause a nutritional imbalance or increase concentrations of toxic ions in soils (Abbas *et al.*, 2015; Ayres and Westcot, 1994).

TDS ranged from 0.6 mg/L to 9.6 mg/L, with an average value of 2.5 mg/L. These values are suitable for irrigation and comparable to results reported by Chen *et al.* (2017) for treated domestic wastewater.

**Table 1. Physicochemical composition of the treated WWTP effluent**

Parameters	Minimum	Maximum	Average	Coefficient of variation
T(°C)	25	26.1	25.6	1.8
pH	6.3	9.5	8.2	12.2
Conductivity (µS/cm)	1922	2924	2401.2	14.6
Na <sup>+</sup> (mg/L)	126.8	193	160.5	15.2
Ca <sup>2+</sup> (mg/L)	226.7	361	270.9	16.1
Mg <sup>2+</sup> (mg/L)	32.6	130.2	78.9	45.4
K <sup>+</sup> (mg/L)	62.1	236.7	104.1	57.4
HCO <sub>3</sub> <sup>-</sup> (mg/L)	32.5	205.01	109.4	62.9
NO <sub>3</sub> <sup>2-</sup> (mg/L)	132.4	340.1	219.6	39.5
Cl <sup>-</sup> (mg/L)	1.4	3.5	2.3	38.8
PO <sub>4</sub> <sup>3-</sup> (mg/L)	217.3	594.8	392.6	40.0
SO <sub>4</sub> <sup>2-</sup> (mg/L)	52.9	105.8	76.9	21.7
TDS (mg/L)	0.6	9.6	2.5	26.5
TH (°f)	2.7	6.7	5.1	28.9



**Fig. 2. Piper diagram of the treated WWTP effluent (data adjusted at 25 °C)**

Conductivity of the treated effluent ranged between 1922.0 µS/cm and 2924.0 µS/cm, with an average value of 2401.2 µS/cm. These values, above 1500 µS/cm, indicate high conductivity with slight to moderate salinity hazard for irrigation (WHO, 2013). In Côte d'Ivoire, no specific restrictions exist for conductivity. The treated effluent complied with WHO recommended standards for reuse in irrigation without causing stress or toxicity to plants (WHO, 2013). However, this type of water requires proper management and favorable drainage conditions, as salinity problem can develop if leaching requirements are not met. The high conductivity of the treated effluent may be due to dissolved salts (chlorides, sulfates, bicarbonates and nitrates), detergents, cleaning products and dissolved organic matter from households (Jones *et al.*, 2016; Brown *et al.*, 2017; Smith *et al.*, 2018; Johnson *et al.*, 2019; Lee *et al.*, 2020; Garcia *et al.*, 2021). High conductivity reduces the water available to plants, even when the soil appears wet. Conductivity values were higher than those obtained by Salomon *et al.* (2024) for similar effluent in January, likely due to increased water evaporation process in May – June, when the average temperature is 25.6 °C, compared to 16 °C in January.

Wastewater with high solid can clog soils, affecting porosity and chemical composition when concentration reach 100 – 350 mg/L (Jiménez, 2006). Cation concentrations in the treated effluent followed the order: Ca<sup>2+</sup> > Na<sup>+</sup> > K<sup>+</sup> > Mg<sup>2+</sup>. Calcium ion (Ca<sup>2+</sup>) concentration fluctuated slightly over time, from 226.7 mg/L to 361.0 mg/L (average of 270.9 mg/L) and sodium ions (Na<sup>+</sup>) concentration was between 126.8 mg/L to 193.0 mg/L (average value 160.5 mg/L). These values complied with standards for discharge and reuse for irrigation of salt-tolerant crops, well-drained soils or soils with good permeability. Potassium (K<sup>+</sup>) ranged from 62.1 mg/L to 236.7 mg/L (average of 104.1 mg/L) and Mg<sup>2+</sup> concentration varied from 32.6 mg/L and 130.2 mg/L (average of 78.9 mg/L). Concentrations of these two cationic ions meet standards for discharge and reuse for irrigation, but fluctuated widely over time, with coefficient of variation (CV) of 45.4% and 57.4%, respectively for K<sup>+</sup> and Mg<sup>2+</sup>. Anion concentrations of the treated effluent followed the order: PO<sub>4</sub><sup>3-</sup> > NO<sub>3</sub><sup>-</sup> > HCO<sub>3</sub><sup>-</sup> > SO<sub>4</sub><sup>2-</sup> > Cl<sup>-</sup>. Phosphate (PO<sub>4</sub><sup>3-</sup>) ranged from 217.3 mg/L to 594.2 mg/L (average 392.6 mg/L), nitrate (NO<sub>3</sub><sup>-</sup>) from 132.4 mg/L to 340.1 mg/L (average 219.6 mg/L), bicarbonate (HCO<sub>3</sub><sup>-</sup>) from 32.5 mg/L to 205.0 mg/L (average 109.4 mg/L), sulfate (SO<sub>4</sub><sup>2-</sup>) from 52.9 mg/L to 105.8 mg/L (average 76.9 mg/L), and chloride (Cl<sup>-</sup>) from 1.5 mg/L to 3.5 mg/L (average 2.3 mg/L). These anion

concentrations meet recommended standards for discharge and reuse for irrigation, with slight to moderate restrictions (WHO, 2013) and exhibited significant variability with coefficient of variation of 62.9%, 39.5%, 38.8%, 40%, 21.7%, respectively for bicarbonate ( $\text{HCO}_3^-$ ), nitrate ( $\text{NO}_3^-$ ), chloride ( $\text{Cl}^-$ ), phosphate ( $\text{PO}_4^{3-}$ ), and sulfate ( $\text{SO}_4^{2-}$ ). Total hardness ranged from 2.7 and 6.7 °f, with an average of 5.1 °f, indicating slightly soft water suitable for irrigation. High hardness can induce precipitation of calcium and magnesium salts, clogging irrigation systems. The hydrofacies of the treated effluent, determined by Piper diagram (Figure 2), was of chloride – sulfate, calcium – magnesium type, characteristic of water with high concentrations of calcium and magnesium cations along with sulfate and chloride anions.

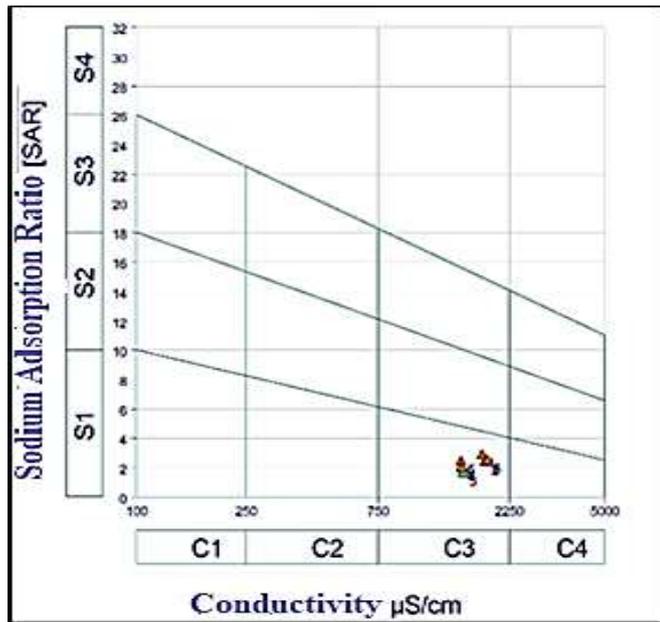


Fig. 3. Evolution of Sodium adsorption rate as function of conductivity (data adjusted at 25 °C)

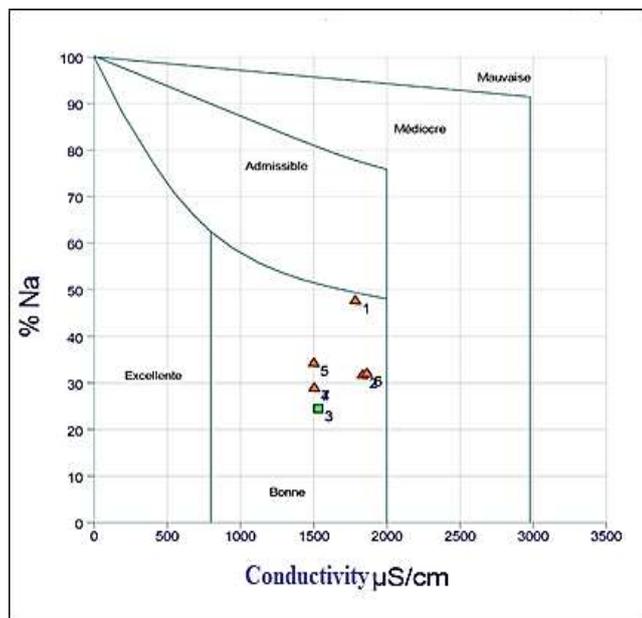


Fig. 4. Evolution of Sodium percentage as function of conductivity (data adjusted at 25 °C)

**Agronomic Water Quality Parameters:** Table 2 presents several parameters used to assess irrigation quality of the treated effluent from the WWTP of Korhogo. As shown in the table 2, SAR or sodium hazardous ranged between 8.9 to 14.0 meq/L, with an average value of 12.1 meq/L. Most of water samples (85.7%) had SAR values between 10 – 18 meq/L, while 14.3% had SAR below 10 meq/L.

These results indicated that the quality of the treated effluent ranged from good to excellent for irrigation in term of salinity. The treated effluent can be used for irrigation without risk of soil degradation or reduction of infiltration capacity. High SAR can cause several problems, including plant toxicity, calcium deficiency, decrease sorption of dissolved organic carbon, decrease of soil fertility and crop productivity (Imran *et al.*, 2010; Mavi *et al.*, 2012). Sodium percentage (Na%) ranged from 23.7 and 38.7 %, with an average value of 31.5 %. All water samples had Na% values between 20 – 40%, indicating that Na was not in excess and water quality was suitable for irrigation. Excess sodium in irrigation water can lead to accumulation in the soil, where sodium replaces calcium and magnesium adsorbed on soils particles and causing particle dispersion (Todd, 1980). Kelly ratio ranged from 0.3 to 0.6, with an average value of 0.5. All water samples had KR below 1, confirming that Na content was not excessive and water quality was suitable for irrigation. Consequently, the risk of leaf damage to sensitive plants from sprinkler irrigation is very low (Nguyen *et al.*, 2018). All quality parameters indicate that the minerals were present in the treated effluent from WWTP of Korhogo were at safe concentrations and suitable for agricultural purpose.

**Assessment of salinization and risks of alkalisation:** Salinization and risks of alkalisation were assessed indirectly using conductivity, SAR and Na%. Figure 3 present the evolution of SAR according to conductivity. It gives information on salinization and alkalization risks. The treated effluent was C3S1 type, characteristic of water generally suitable for the irrigation of crops moderately tolerant to salts on well-drained or well-permeable soils. This water can be used for irrigation without any risk of soil salinization or alkalization. The evolution of Na% as a function of conductivity is presented in figure 4. This figure gives information on exchangeable percentage of sodium in soil. According to figure 4, all water samples were suitable for irrigation, ranged from good to permissible quality.

## CONCLUSION

The present study assessed the suitability of the treated effluent from WWTP of Korhogo for irrigation. The physicochemical composition of the effluent and agronomic quality parameters complied with WHO recommended standards for discharge and reuse in irrigation. Cation concentrations in the water were relatively stable, while anion concentrations fluctuated widely. The Piper diagram demonstrated that the hydrofacies of the treated effluent was of chloride – sulfate, calcium – magnesium type, characteristic of water with high concentrations of calcium and magnesium cations along with sulfate and chloride anions. All agronomic quality parameters demonstrated that mineral concentrations were within safe limits and suitable for irrigation. The treated effluent was classified as C3S1, characteristic of water acceptable for irrigation of crops moderately tolerant to salts on well-drained or well-permeable soils. This type of water can be used for irrigation without risk of soil alkalization or alkalization. However, a continued long-term use should be considered under appropriate monitoring and management.

## REFERENCES

- ABBAS H.H., RASHED H.S.A., EL-ZAEATY D.E.-D.A.A. (2015). Assessment of wastewater quality for irrigation purposes *Annals of Agric. Sci.*, Moshtohor 53(4), 765–774.
- AYRES, R.S. AND WESTCOT. D.W, 1994. Water quality for agriculture. Irrigation and Drainage Paper No. 29 Rev. 1. Rome Food and Agriculture Organization of the United Nations. Rome.
- BORENA F.R. and HASSEN J.M. (2022). Impacts of Soil Salinity on Irrigation Potential: In the Case of Middle Awash, Ethiopian Review. *Open Access Library Journal*, 9, 1-18. doi: 10.4236/oalib.1108123.
- BROWN C., OKI L., BROOKS J., P., BROWN M. B., STEELE M., ET JAY-RUSSELL M. T. (2017). Evaluating the suitability of

- reclaimed water quality for agriculture in the southeastern United States. *Agricultural Water Management*, 179, 160-168.
- BURINGH P. (1977). Food Production Potential of the World. *World Development*, 5 (5-7), 477-485. [https://doi.org/10.1016/0305-750X\(77\)90051-1](https://doi.org/10.1016/0305-750X(77)90051-1)
- CEAEQ (2016). Détermination de l'alcalinité et de l'acidité: méthode titrimétrique automatisée. MA.315–Alc-Aci1.0, Révision 3. Ministère de l'Environnement et de la Lutte contre les changements climatiques. Centre d'expertise en analyse environnementale du Québec, 12 p.
- CEAEQ (2020a). Détermination des anions: méthode par chromatographie ionique. MA. 300 – Ions 1.3, révision 6. Ministère de l'Environnement et de la Lutte contre les changements climatiques. Centre d'expertise en analyse environnementale du Québec, 12p.
- CEAEQ (2020b). Détermination des métaux: méthode par spectrométrie de masse à source ionisante au plasma d'argon. MA. 200 – Mét. 1.2, révision 7. Ministère de l'Environnement et de la Lutte contre les changements climatiques. Centre d'expertise en analyse environnementale du Québec, p.36
- CEAEQ (2023). Détermination des solides dissous totaux et volatils: méthode gravimétrique. MA. 115 – S.D. 1.0 (révision 6). Ministère de l'Environnement et de la Lutte contre les changements climatiques. *Centre d'expertise en analyse environnementale du Québec*, p.8.
- CHEN Y., LIU Y., ZHANG C., ZHENG L. ET ZHANG H. (2017). Influence of treated wastewater on soil properties and crop productivity. *Journal of Environmental Management*, 198(Part 1),1-8.
- FAO (2002). Crops and drops making the best use of water for agriculture. Rome, Food and Agriculture Organization of United Nations.
- GARCIA M., HERNANDEZ L., PEREZ A., RODRIGUEZ D. ET MARTINEZ J. (2021). Evaluation of the suitability of reclaimed wastewater for irrigation purposes: A case study in the Canary Islands, *Water*, 13(3), 356.
- GLEICK PH (2000). The world's water 2000 – 2001: the biennial report on freshwater resources. Washington, DC, Island Press.
- IMRAN M., MAQSOOD M.A., RAHMATULLAH, KANWAL S. (2010). Increasing SAR of irrigation water aggravates boron toxicity in maize (*Zea mays* L.). *Journal of Plant Nutrition*, 33 (9), 1301-1306, 10.1080/01904167.2010.484091
- JIMÉNEZ B. (2006). Irrigation in Developing Countries using Wastewater. *International Review for Environmental Strategies*, 6(2), 229 – 250.
- JOHNSON B., SMITH C., ANDERSON D., WILLIAMS E. ET BROWN F. (2019). Nutrient and salt content of reclaimed water used for agriculture in a semi-arid environment. *Agriculture, Ecosystems & Environment*, 269, 13-20.
- JONES D., SMITH A., WILLIAMS B., BROWN C. ET JOHNSON E. (2016). Water quality of recycled water used for irrigation: A case study of metropolitan Adelaide, South Australia. *Journal of Hydrology: Regional Studies*, 8, 9-19.
- KELLY W. (1963). Use of saline irrigation water”, Ed, Soil Science, 95:355–391p.
- LEE D., KIM S., PARK J., CHOI J. ET HAN S. (2020). Water quality of reclaimed wastewater and suitability for irrigating agricultural crops in Korea. *Journal of Environmental Management*, 264, 110461.
- MAVI M. S., SANDERMAN J., CHITTLEBOROUGH D. J., COX J. W., MARSCHNER P. (2012). Sorption of dissolved organic matter in salt-affected soils: effect of salinity, sodicity and texture. *Science of Total Environment* 435–436, 337-344, 10.1016/j.scitotenv.2012.07.009
- NGUYEN P. D., TOUMBOU B., DUCHESNE S., KOKUTSE N., VILLENEUVE J. P. (2018). Évaluation de l'impact de la pollution diffuse sur la qualité de l'eau en rivière avec données restreintes : cas d'application du bassin versant de la rivière Cau. *Revue des sciences de l'eau / Journal of Water Science*, 31(3), 293-312, <https://doi.org/10.7202/1054308ar>.
- RICHARDS L. (1954). Diagnosis and improvement of saline and alkaline soils. US Department of Agriculture, Washington, DC.
- ROUABIA A. E. K. and DJABRI L. (2010). L'irrigation et le risque de pollution saline, Exemple des eaux souterraines de l'aquifère miocène de la plaine d'El Ma Labiod. *Larhyss Journal*, 8, 55 – 67.
- SALOMON K. Y., SEYHI B., KONAN N. L. (2024). Agricultural Valorization of Treated Effluent from Korhogo Wastewater Treatment Plant. *Journal of Agriculture and Ecology Research International* 25 (6):9-23. <https://doi.org/10.9734/jaeri/2024/v25i6635>.
- SCOTT C. A., FARUQUI N., RASCHID-SALLY L. ET BRAECKMAN L. (2018). Wastewater reuse for agriculture: a review of water quality standards and withdrawal regulations. *Water International*, 43(6), 787-802, DOI: 10.1080/02508060, 2018,1512761.
- SMITH J, BROWN A., JOHNSON C. (2018). Water scarcity and its impact on food security. *Journal of Water and Food Security* 5(2), 102-115
- TODD K. and MAYS L.W. (2004). Groundwater hydrology. Wiley J. and Sons Inc. Third Edition, New York, USA, 656p. ISBN: 978-0-471-05937-0.
- WHO (2013). Guidelines for the safe use of wastewater, excreta and greywater - Volume 2. Wastewater use in agriculture. World Health Organization, United Nations Environment Programme. p 222, ISBN: 92 4 154683 2
- WILCOX L. (1955). Classification et usages des eaux d'irrigation. Circulaire USDA n°969, Washington, DC 165pp.

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