Determining greywater quality and its potential impact on the environment and okra seeds germination

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ABSTRACT

Proper wastewater management is an essential step of the path to a healthier life, especially in crowded areas such as universities. The objective of this study was to contribute to the management of greywater generated from the restaurant of university Joseph KI-ZERBO in Burkina Faso. To do this, a qualitative characterization of the different types of greywater produced in the restaurant and an evaluation of the impact of these waters on the germination of okra seeds were carried out. The physico-chemical characterization has shown high organic pollution of kitchen and shower greywater with average values of 2717.17 and 846.17 mg/L for COD and 1251 and 566.75 mg/L for BOD_5 respectively. In addition, the nutrients contents were high (average values of 632.70 and 491.33 mg/L for NO_3^- ; 46.33 and 48.88 mg/L for PO_4^{3-}) and could have a negative impact on the environment like the eutrophication of rivers in the "Bangr Weogo Park" used for leisure in Ouagadougou. For all greywater sources, the microbiological pollution was high with fecal coliforms and *E. coli* contents of 7.8 x 10^4 to 1.83 x 10^6 CFU/100mL and 6.57 x 10^4 to 2.08 x 10^6 CFU/100mL respectively; in addition, they contained helminth eggs such as *Ascaris lumbricoides* at an average concentration of 43 eggs/L, highlighting the potential health risk. Besides, the Sodium Absorption Ratio (SAR) values were high ranging from 9.89 to 31.66. Despite the presence of chemical and microbial pollutants, the different greywaters allowed the germination of okra seeds. However, parameters such as sodium, conductivity and SAR influenced the elongation of the radicles. Given the ecological and agricultural advantages that can be derived from good greywater management in the Sahelian context, their treatment could be undertaken through biological methods since the COD/BOD_5 ratios were less than 3.

Keywords: *E. coli*, fecal coliforms, greywater, organic pollution, Ouagadougou.

1. INTRODUCTION

Developing countries are facing problems of access to drinking water and adequate sanitation services. In Burkina Faso, the national survey on access to sanitation conducted in 2015, revealed that only 12% of the rural population had access to sanitation compared to 34.2% in urban areas (PN-AEUE, 2016). Despite an increase to 22.6% in 2018 according to the Ministry of Water and Sanitation, more than two thirds of Burkinabè still do not have adequate excreta management systems and nearly 85% of wastewater is discharged into the environment without treatment (Government Information System, 2019). This practice can spread diarrheal and vector born diseases like malaria and lead to polluted environment. In addition, the world's arid regions are facing increasing water scarcity due to climate change and population growth (WU *et al.*, 2013). In sub-Saharan Africa, this shortage is one of the major constraints to the development of agriculture in semi-arid and arid areas (JURY *et al.*, 2007). For continuous food production, it is necessary to have a continuous supply of water for irrigation.

This situation is more critical in crowded sites like academia where students and staff meet every day. University Joseph KI-ZERBO (UJKZ) is the largess high school in Burkina Faso with around 50,000 students. The greywater produced from the university restaurant (which serves between 9,000 and 10,000 daily meals) is discharged, without treatment, into an open drain leading to "Bangr-wéogo" urban park, used for leisure.

Greywater is generated from households' activities such as kitchen, shower and laundry; however, it can contain pollutants and pathogens (MAÏGA *et al.*, 2014) which can spread to the environment and deteriorate the quality of surface water and pose public health threat. It can also contribute to the proliferation of invasive plants such as water hyacinth followed by eutrophication of wetlands and surface water reservoirs located in the "Bangr-wéogo" park. A study showed that greywater is the largest fraction of domestic wastewater in terms of volume while being the least polluted fraction due to the lack of fecal pollution (BHAUSAHEB *et al.*, 2010). The use of greywater in agriculture is strongly encouraged as it contributes to reduce the growing pressure on water resources (SATO *et al.*, 2013).

In this study, we will evaluate the potential of reuse of greywater produced in the restaurant of the Joseph KI-ZERBO University. The objectives of this study were to (i) Evaluate the physico-chemical and microbiological quality of the different sources of greywater produced in the restaurant; (ii) Assess the compliance of this greywater with environmental discharge standards in Burkina Faso; (iii) Determine the effect of the raw greywater on the germination of the seeds of okra.

2. MATERIAL AND METHODS

2.1. Study site

The study was conducted from November 2018 to January 2019 in the restaurant of University Joseph KI-ZERBO (1°30'1.52'' West; 12° 22'38.63'' North) located in the capital Ouagadougou. This university is the largest in term of area and number in the country with 50,000 students and 10,000 meals served per day.

2.2. Collection of greywater samples

In order to collect the greywater samples for analysis, onsite visits were organized to elaborate the greywater production and discharge scheme (Figure 1). Greywater samples were collected in a weekly basis from five sampling points: kitchen oultet (KO), shower outlet (SO); hand washing outlet; kitchen-shower raw greywater (RG); pretreated shower-hand washing greywater (PG) (Figure 1) using the instant manual sampling method (RODIER *et al.*, 2009). Each sample was collected in 1 liter were taken to determine the microbiological, physical and chemical parameters respectively. The samples were directly analyzed or stored in a freezer (4°C) for analysis within the following 24 h.

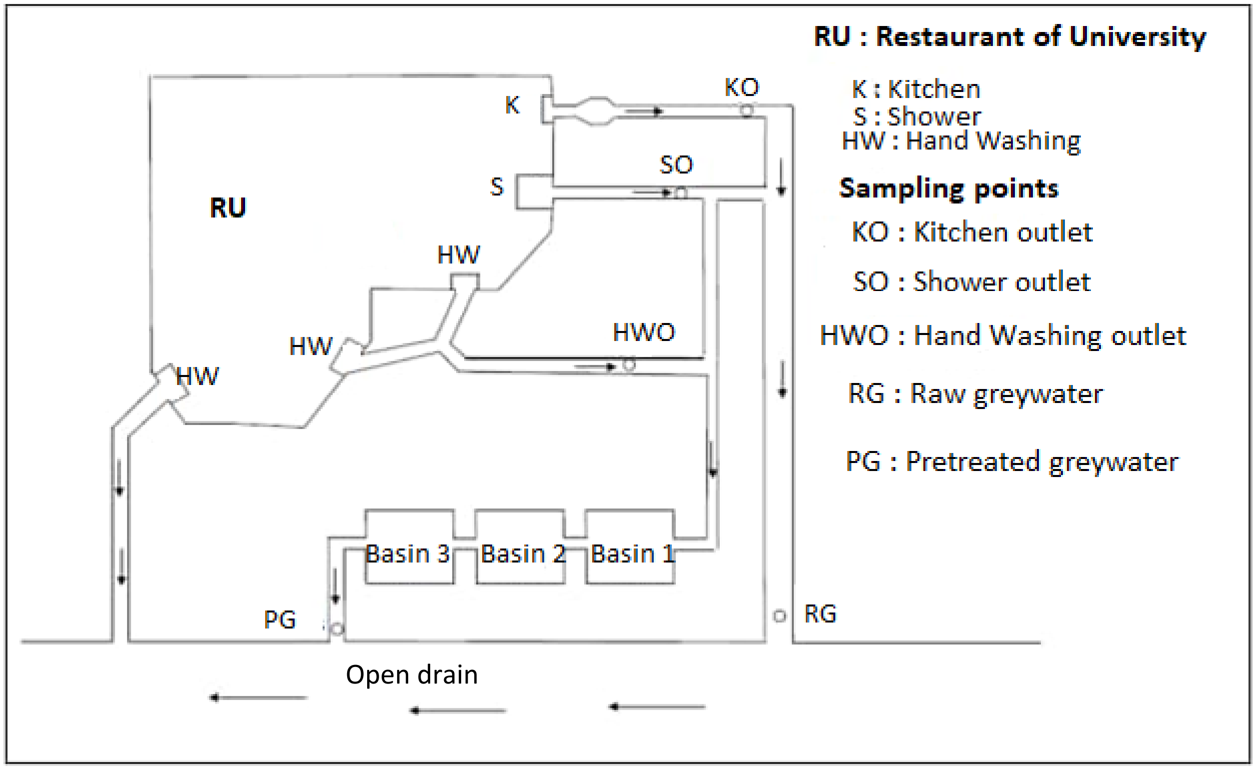

Figure 1: Water drainage plan and sampling points

Kitchen, shower and hand washing are the 3 main sources of greywater and are discharged into the open drain. A mixture of shower and hand washing greywater passes through 3 ponds in series before being discharged. A third drain contained hand washing greywater. The arrows indicate the direction of the greywater for discharge.

2.3. Determination of the physical, chemical and microbiological quality of the greywater

The characteristics of the greywater can (i) serve as basis for the evaluation of the risk related to the discharge of untreated greywater in the open drain and (ii) be used for the design of a treatment system. Therefore, several parameters were determined.

In situ measurements were made for pH, temperature and electrical conductivity (EC) using a multi-parameter WTW.

The physical and chemical characteristics were evaluated through the assessment of chemical oxygen demand (COD), 5-days biochemical oxygen demand (BOD_5), suspended solids (SS), nutrients content (nitrate, nitrite, ammonium and ortho phosphate), calcium, magnesium and sodium. SS were determined by a gravimetric method using glass microfiber filters Whatman (porosity 1.5 µm). The nutrients were determined by spectrophotometric method using the DR 3900 spectrophotometer. Kjeldahl nitrogen was determined by the Kjeldahl method. Calcium and magnesium were determined titrimetrically using a standard ethylenediamine tetraacetate (EDTA) technique. Sodium was measured by flame photometry. All analyses were conducted according to Standard Methods (APHA, 1998).

In order to determine the suitability of the greywater for irrigation, the Sodium Adsorption Ratio (*SAR*) was evaluated from the results of Na, Ca and Mg using Equation 1.

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

Microbiological pollution was determined by assessing the fecal indicators (*Escherichia coli*, fecal coliforms and enterococci) and pathogen (*Salmonella*, protozoan cysts and helminth eggs) contents. After an appropriate samples dilution in accordance with the procedure in Standard Methods for the Examination of Water and Wastewater (APHA, 1998), the spread plate method was used to grow the bacteria. For the growth of *E. coli* and fecal coliform, Chromocult Coliform Agar was used as the culture medium while M-*Enterococcus* agar was used for enterococci assessment. The *Salmonella* test was carried out in two phases: an enrichment phase in the Rappaport medium followed by subculture on the Rambach *Salmonella* Agar selective medium. The method of SCHWARTZBORD *et al.*, (1998) was used to assess the contents of helminth eggs and protozoan cysts.

2.4. Greywater phytotoxicity tests on okra seeds

In order to test the suitability of the raw greywater for reuse in gardening, phytotoxicity tests were performed.

2.4.1. Experimental design

The study was conducted using the seeds of okra from the Sahelian zone of Burkina Faso (ecotype B2). In order to determine the effect of water quality on the germination of the seeds, the experiment was conducted with 4 types of greywater (kitchen, shower, mixture kitchen-shower and the pretreated greywater). Distilled water was used as a control. For each type of water, 5 Petri dishes containing 10 seeds per dish were used. The Petri dishes were arranged in 5 completely randomized blocks corresponding to the 5 types of irrigation water. Hydrophilic cotton was placed in each Petri dish to serve as a moisture-retaining medium. The seeds were weighed individually using a balance and placed into the Petri dishes containing the hydrophilic cotton previously moistened with 5 mL of the specific water source. During the experiment, each block (5 Petri dishes) was watered every two days with one of the 5 types of water source (5 mL per Petri dish).

The test was carried out under laboratory conditions i.e. under brightness of the electric lamps and daylight during the day and at night under darkness until the next day's break.

2.4.2. Measured parameters

After the germination, parameters such as germination rate (*G*) and radicle length (*RL*) were measured daily at the same time until the end of the 7 days trial. The appreciation of the germinated seeds was made by visual observation based on the appearance of the radicle. Germinated seeds were counted manually and *G* was determined according to equation 2:

$$G = \frac{n}{N} * 100 \qquad \text{Equation 2}$$

With *G* = Germination rate; *n* = number of seeds germinated and N = number of seeds tested.

A wire and a graduated ruler were used to measure the length of the radicles.

2.4.3. Statistical analyses

The data were processed using Microsoft Excel software for various calculations (average weight, germination rate etc.). The Analysis of Variance was performed using XLSTAT version 2008.1.01 to compare the effect of the different types of water on the germination and elongation of the seeds. The Tukey test was used to compare the means at the 5% level.

3. RESULTS AND DISCUSSION

3.1. Physical and chemical characteristics of the greywater

The temperatures of kitchen and shower greywater varied from 29.21 to 32.36 and 20.97 to 31.41 respectively (Table I). There is no significant difference between the temperature values of the different greywater sources (Table I). The temperature of the pretreated greywater ranged between 22.16 and 29.69. These values are in accordance with the temperature range of 18 to 30° C, generally reported for greywater (MOREL and DIENER, 2006); they are also in accordance with the standards of 18 to 40 °C for the discharge of wastewater into surface water in Burkina Faso (Decree.2015-1205).

Shower greywater presented an average pH of 8.06. Similar results have been reported by previous studies conducted in Burkina Faso (MAÏGA *et al.*, 2014) with pH values between 7.8 - 9.8. This alkaline condition of shower greywater could be related to the use of various soaps and detergents. Kitchen and mixture kitchen-shower greywater exhibited acidic pH with average values of 4.97 and 4.85 respectively (Table I). The water resulting from washing corn, millet and leaf could have decreased the pH. Indeed, ICARD *et al.*, (2010) obtained a pH values ranging from 4.27 and 5.18 respectively with sorghum and maize wash water in Burkina Faso and Benin. Statistical analysis shows that there is a significant difference between the pH values of different greywater sources (Table I). The pH values obtained from our study are lower than those reported by MAÏGA *et al.*, (2014) for kitchen greywater collected from the rural region of Burkina Faso (average pH of 8-9). The authors attributed this pH to the use of potassium hydroxide for cooking. Based only on the pH values, our kitchen and mixture kitchen-shower greywater do not comply with the standards (6.4 - 10.5) for the discharge of wastewater into surface water in Burkina Faso.

Statistical analysis of EC shows that there is a significant difference between the values of the different greywater sources (Table I). The EC of kitchen and mixture kitchen-shower greywater are high with values of 1230.25 and 1255.83 μS/cm respectively (Table I). Higher values are found in the water from the shower with an average of 1730.60 μS/cm. Low EC of 289.75 μS/cm is found in the pretreated greywater (Table I).

Statistical analysis of the organic matter values (SS, BOD_5, COD) shows that there is a significant difference between the values of the different greywater sources (Table I). Kitchen greywater is significantly loaded in SS, BOD_5, and COD (average values of 1538.86, 1251.00 and 2717.17 mg/L respectively) compared to the other types of greywater (Table I). Several authors have reported similar results. For example, LI *et al.,* (2009) in their study on greywater treatment and reuse reported maximum values of 1460 mg/L and 2050 mg/L for BOD_5 and COD respectively. The presence of high SS in kitchen greywater is due to the presence of food, soap fibers and various detritus (WHO 2006). The lowest values in SS, BOD_5 and COD are found in the pretreated greywater (9.38, 69.47 and 94.33 mg/L respectively).

Table I. Physical and chemical parameters of greywater collected from the 3 main sources and the 2 sites of discharge in the open drain

Greywater source	pH	T °C	EC µS/cm	SS mg/L	BOD_5 mg/L	COD mg/L	NO_3^- mg/L	NO_2^- mg/L	NH_4^+ mg/L	KTN mg/L	PO_4^{3-} mg/L
Kitchen	4.97^{cd} (0.43)	27.29^{a} (2.99)	1230.25^{a} (237.80)	1538.86^{a} (1071.87)	1251.00^{a} (331.29)	2717.17^{a} (1274.5)	632.70^{a} (288.37)	1.47^{a} (0.52)	15.09^{b} (4.89)	23.25^{a} (6.94)	46.33^{ab} (12.04)
Shower	8.06^{a} (0.73)	26.63^{a} (3.10)	1730.67^{b} (799.19)	172.44^{b} (135,18)	566.75^{b} (439.21)	846.17^{bc} (677.47)	491.83^{ab} (474,13)	1.24^{a} (1,25)	91.70^{a} (48.12)	186.32^{b} (134.03)	48.88^{a} (30.41)
Hand washing	5.57^{c} (0.93)	26.48^{a} (2.57)	220.17^{c} (73.57)	148.65^{b} (106.96)	334.08^{bc} (187.62)	534.08^{c} (249.19)	203.82^{bc} (215.73)	0.45^{ab} (0.21)	3.60^{b} (1.68)	7.69^{b} (4.83)	4.65^{c} (4.54)
Mixture kitchen-shower	4.85^{d} (0.17)	25.95^{a} (2.72)	1255.83^{a} (412.17	259.44^{b} (248.52)	1021.42^{a} (306.92)	1356.75^{b} (402.68)	168.62^{bc} (97.95)	0.65^{ab} (0.21)	29.49^{b} (13.76)	41.11^{b} (13.23)	30.00^{b} (5.47)
*Pretreated greywater	6.40^{b} (0.25)	25.97^{a} (2.43)	289.75^{c} (51.49)	9.38^{b} (7.77)	69.67^{c} (16.77)	94.33^{c} (24.86)	40.69^{c} (24.09)	0.12^{b} (0.05)	9.00^{b} (3.83)	13.00^{b} (3.64)	6.66^{c} (2.12)
P-Value	0.001	0.838	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001
Standards for greywater discharge	6.5-10.5	18-40	-	60	40	150	50	1	1	35	5

KTN: Kjeldahl nitrogen; The values in bracket are standard deviation; *Pretreated greywater: mixture of shower and hand washing greywater pretreated through passage in 3 ponds in series. For a given parameter, values with different letters are significantly different.

Therefore, the passage through the ponds in series seems effective in removing the organic and particulate matter although the concentrations remain higher than the national discharge standards in Burkina Faso. It could be important to consider diverting the raw greywater (kitchen-shower) into these ponds for a possible pretreatment to reduce their impact on the environment. Based on the results of BOD_5 and COD, all of the greywater types generated by the restaurant do not meet the standards for discharge into surface water (Decree 2015-1205).

To verify the biodegradability of the greywater produced, the COD/BOD_5 ratios were determined (Table II). The ratios were less than 3 whatever the greywater source. MAÏGA *et al.,* (2014) reported similar results on greywater produced from rural households in Burkina Faso. Therefore, the greywater generated from the restaurant can be considered as biodegradable and can be treated biologically (MOREL and DIENER, 2006).

Table II. Values reflecting the COD/BOD_5 ratio of greywater from the university restaurant.

Greywater source	Kitchen	Shower	Mixture kitchen-shower	Pretreated greywater	Biodegradability critera
DCO/DBO_5 ratio	2.17	1.49	1.33	1.35	< 3

Nitrogen and phosphorus are important parameters in greywater given their fertilizing value for plants. Statistical analysis of mineral pollution values (NO_3^-, NO_2^-, NH_4^+, NTK, PO_4^{3-}) shows that there is a significant difference between the values of the different greywater sources (Table I). For nitrate, the highest concentration was recorded from kitchen greywater (623.7 mg/L) followed by shower greywater (491.83 mg/L) (Table I). The lowest concentration was recorded at the outlet of the ponds with an average value of 40.69 mg/L. The concentration of ammonia from the shower greywater is high (91.70 mg/L) compared to the other sources. The lowest concentration of ammonia is observed at the outlet of the ponds (9.00 mg/L). The highest concentration of Kjeldahl nitrogen (NTK) was observed in the shower greywater (186.32 mg/L) while the lowest value was obtained in the pretreated greywater (13.00 mg/L). High ammonia concentrations in kitchen water have been attributed to the nitrogen contained in food proteins according to MOREL and DIENER (2006). The highest value of ortho-phosphate is obtained from shower greywater (48.88 mg/L) followed by kitchen greywater (46.33 mg/L). The lowest concentration derived from the pretreated greywater with a value of 6.66 mg/L (Table I). High concentrations of orthophosphate in greywater are attributed to household detergents and phosphorus soaps (MOREL and DIENER, 2006; ABU GHUNMI *et al.,* 2008). In agriculture, these nutrients can be beneficial to the growing plants. For example, high nitrogen and phosphorus in irrigation water can promote plant growth (TRAVIS *et al.*, 2010). However, high nitrate concentrations can have several negative impacts on crops such as delays in ripening (N'DIAYE *et al.,* 2011). They can also contribute to a degradation of the water quality through an accelerated development of algae and plants (RODIER *et al.*, 2009). Therefore, the discharge of the greywater into the open drain can contribute to the eutrophication of the "Bangr Weogo" park (which is used for leisure) and the downstream rivers.

Furthermore, greywater contains specific ions that can negatively impact the irrigated soil and crops. For example, Sodium Adsorption Ratio (*SAR*) describes the amount of excess Na^+ compared to the Ca^{2+} and Mg^{2+} cations. The *SAR* values of the greywater sources ranged from 9.89 (pretreated greywater) to 31.66 (shower). High *SAR* values in greywater can be explained by the use of soap and detergent. HIJIKATA *et al.* (2013) showed that Na+ and major cations in the pilot gardens were mainly from greywater. However, Na+ inhibits plant growth by disrupting water uptake into the roots, dispersing soil particles, limiting root growth, and reducing nutrient availability through competition with major ions in the substrate (FRANZEN, 2007). SANGARE *et al.* (2015) showed that the application of greywater on an irrigated perimeter could lead to an increase in soil alkalinity over time. WHO (2006) recommended to use water with a *SAR* between 3 and 9 even if the sodium concentrations meet the standards of reuse (<300 mg/L).

3.2. Microbiological characteristics and related risks

The results show that all types of greywater are loaded in fecal indicators (*E. coli*, fecal coliforms and enterococci) (Table III). The highest concentrations of all indicators were observed in the kitchen greywater. For example, the average *E. coli* content was 2.08×10^6 CFU/100mL while the lowest value was 6.57×10^4 CFU/100mL (pretreated greywater). The lowest content in enterococci (5.23×10^5 CFU/100mL) and fecal coliforms (7.82×10^4CFU/100mL) were obtained from the shower and pretreated greywater respectively.

Table III. Average contents of fecal indicators in greywater collected from the restaurant

Fecal indicator (UFC/100ml)	Kitchen	Shower	Mixture kitchen-shower	Pretreated greywater	Standards for greywater discharge
E. coli	2.08×10^6 (1.39×10^6)	1.26×10^6 (2.62×10^6)	3.05×10^5 (2.98×10^5)	6.57×10^4 (5.36×10^4)	2.00×10^3
Fecal coliforms	6.05×10^6 (5.11×10^6)	1.38×10^6 (2.72×10^6)	1.83×10^6 (2.25×10^6)	7.82×10^4 (5.70×10^4)	2.00×10^3
Enterococci	$1.96.10^7$ (5.42×10^7)	5.23×10^5 (8.97×10^5)	4.03×10^6 (8.46×10^6)	1.71×10^6 (4.89×10^6)	-

Standard deviation under brackets

Our results on fecal contamination indicators are lower than those found by MAÏGA *et al.*, (2014). High loads in fecal indicators of shower and kitchen greywater were attributed to the possible contamination with feces during the shower (LI *et al.*, 2009) and by washing vegetables and raw meat in the kitchen (WHO, 2006). In addition, the growth of fecal indicators is promoted by easily degradable organic compounds present in kitchen greywater (WHO, 2012). As we can see, the pretreatment performed by the 3 ponds in series seems not to be efficient in eliminating the microbiological pollution since the values remain higher than the standards. None of the greywater produced is in compliance with the Burkina Faso standards for wastewater discharge into surface water fixed at 2000 CFU/100 mL for *E. coli* and fecal coliforms (Decree 2015-1205). In addition, they do not meet the WHO (2006) standards for restricted irrigation ($<10^4$ CFU/100 mL). Indeed, the use of untreated wastewater in irrigation may involve a health risk related to the presence of *E. coli* and certain protozoa. For restricted irrigation, the WHO in 2006 guideline recommends a reduction of pathogens by 2 to 3 logarithmic units.

In order to raise awareness on the potential risk associated with the discharge of such greywater, the pathogen content was evaluated. Hence, in the mixture kitchen-shower and the pretreated greywater, the analysis highlighted the presence of presumptive *Salmonella*. Indeed, a study conducted by KIM *et al.,* (2009) showed the presence of 5,400 Salmonella enterica Typhimurium CFU-100 mL^{-1} in the grey water of 170 apartments in the United States. DALAHMEH *et al.*, (2011) also reported the presence of 1290 MPN 100 mL^{-1} of *Salmonella* *typhi* in the greywater of households in the Jerash refugee camp in northern Jordan. The contamination of greywater by *Salmonella* would probably be due to fecal cross-contamination. In fact, the presence of *Salmonella* in these greywaters could be explained by their potential contamination with the feces of infected animals (birds) visiting the site as indicated by BAUDART *et al.*, (2000); in addition, they could be contaminated by fruits and vegetables irrigated with contaminated water (LIU *et al.*, 2018).

In addition, the parasitological analysis revealed the presence of *Ascaris lumbricoides* eggs (Figure 2) in the pretreated greywater at a relatively high concentration of 43 eggs /L. These eggs probably come from the feces of animals such as birds (AKPO *et al.*, 2013) frequently found on the ponds. The presence of helminths in greywater constitutes a health risk. Indeed, they can cause various infectious diseases, mostly affecting the gastrointestinal system (WHO, 2006).

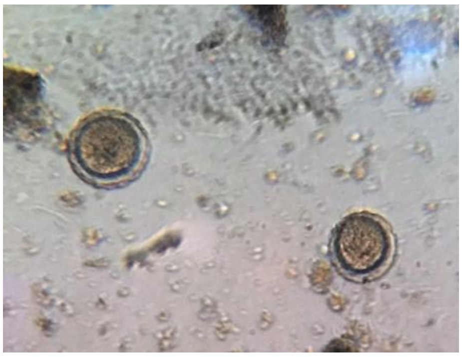

Figure 2: Eggs of *Ascaris lumbricoides*

A possible valorization of greywater could be its reuse in gardening especially in arid regions such as Burkina Faso. To which extent the greywater generated from the restaurant can be reused in gardening?

3.3. Greywater reuse potential

3.3.1. Germination rate

All of the greywater sources allowed the germination of okra seeds at varying rates (Figure 3). In general, the germination occurred in the first 3 days (2 days for distilled water). In addition, all seeds germinated while distilled water was used. In contrast, for the greywater sources *vs* distilled water, lower germination rates were obtained (90% for kitchen, 92% for hand washing and mixture kitchen-shower, and 96% for shower and pretreated greywater). SONJA *et al.* (2011) reported similar results of 100 % germination rate of corn seeds using distilled water. These findings could be explained by the fact that distilled water is almost free of mineral elements with an almost zero amount of salt and is therefore, easily absorbed by seeds which already have their own sufficient nutritive reserves (Pm = 0.0644g) for the germination process.

However, the ANOVA analysis (Tukey test at 5% level) revealed that the germination rates obtained with the five types of water sources were not significantly different. Therefore, greywater could be used as water source to germinate the seeds of okra.

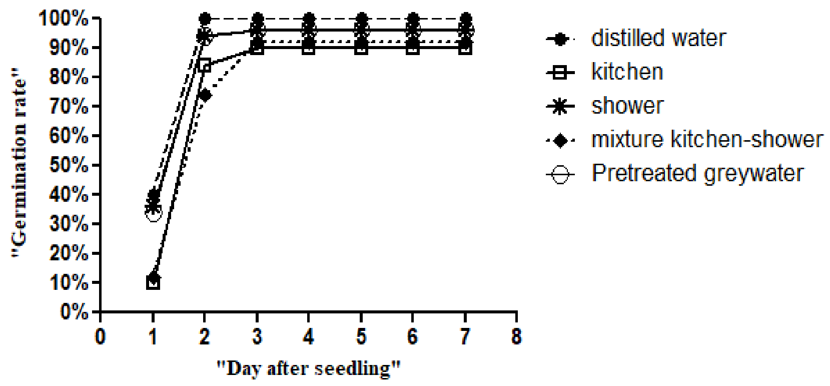

Figure 3: Evolution of the germination rate of okra seeds according to the type of water used for watering.

After the germination of seeds, the following step is the growth of radicle. How do different water sources affect this essential phase?

3.3.2. Radicle growth

After the germination, all tested water sources allowed the lengthening of the radicles of the germinated seeds, but in different ways. For the radicles, the maximum lengths reached were 2.6, 1.6, 1.5, 1.4 and 1.1 cm for pretreated greywater, mixture kitchen-shower, distilled water, kitchen and shower respectively (Figure 4).

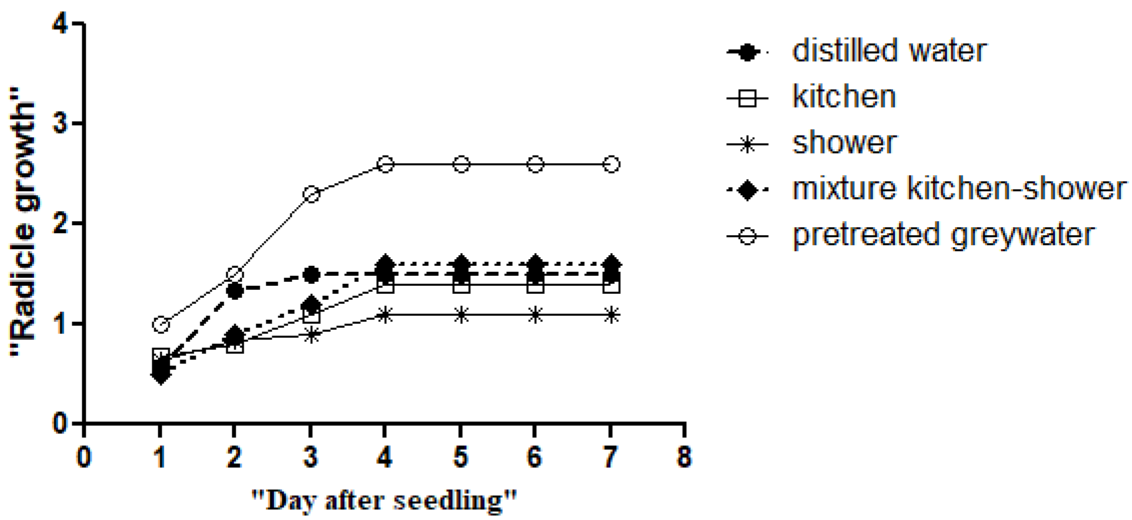

Figure 4: Evolution of the growth of radicles of okra seeds according to the types of irrigation water

The analysis of variance (Tukey test at the 5% level) revealed that the effects of the irrigation waters on the growth of the radicles were significantly different (Table IV). For example, the pretreated greywater significantly improved the radicle growth compared to the shower greywater ($P < 0.0001$) or the kitchen greywater ($P = 0.001$). Hence, the pretreated greywater allowed the best radicle elongation (2.6 cm) while the shortest length is obtained with shower greywater (1.1 cm).

Irrigation water can have different effects on the parameters of germination depending on its quality i.e. mineral contents (sodium. potassium), pH, EC and *SAR*. The low growth of radicles obtained from shower, kitchen and mixture kitchen-shower greywater can be explained by their high sodium contents (93.70, 93.10 and 96.10 mg/L respectively) as well as the high EC and *SAR* compared to the other water sources. Our results are comparable to those reported by NANA *et al.*, (2019) who showed that watering okra seeds with wastewater that has high EC (1284 µS/cm) and high *SAR* (80.28) could have adverse effects on roots growth. As reported by SAWADOGO *et al.*, (2014), irrigation with greywater that has a high conductivity of about 1800 µS/cm could have a negative effect on plant production and health.

Table IV. Effects of five types of irrigation water on the elongation of radicles of germinated okra seeds.

Source of irrigation water	Average radicle length (cm)
Pretreated greywater	2.6^{ab}
Distilled water	1.6^{bc}
Mixture kitchen-shower	1.5^{bc}
Kitchen	1.4^{c}
Shower	1.1^{c}

The radicle lengths with no letter in common are significantly different

4. CONCLUSION

This study highlighted that the greywater generated from the restaurant do not comply with the national standards for the discharge of wastewater into surface water. Indeed, they contain chemical and microbial pollutants that can negatively impact humans, animals and environment. The nutrients for example can contribute to the eutrophication of the water plan in the "Bangr Weogo" park used for leisure and the downstream rivers.

The different greywater sources allowed the germination and elongation of the radicles of okra seeds (even differently) owing to their nutrients contents. However, the greywater sources elongated slowly the radicles than the pretreated greywater because of the high *SAR*, EC and sodium content. They cannot be reused directly in gardening according to WHO standards for the reuse of wastewater, excreta and greywater in agriculture.

Given the ecological and agricultural advantages that can be derived from good greywater management in the Sahelian zone, their treatment could be undertaken. The COD/BOD_5 ratios were less than 3 (which reflect their biodegradability) meaning they can be treated by biological methods.

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