**East African Scholars Journal of Agriculture and Life Sciences**
*Abbreviated Key Title: East African Scholars J Agri Life Sci*
ISSN 2617-4472 (Print) | ISSN 2617-7277 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-4 | Issue-1 | January-2021|

DOI:10.36349/easjals.2021.v04i01.004

**Research Article**

# Impact of Wastewater from Coffee Washing Stations on Aquatic Invertebrates

Dushimirimana Séverin*, Rwasa Denis

Ecole Normale Supérieure (ENS)
Boulevard Mwezi Gisabo, PoBox 6983 Bujumbura-Burundi

**Article History**
**Received:** 22.12.2020
**Accepted:** 08.01.2021
**Published:** 30.01.2021

**Journal homepage:**
http://www.easpublisher.com

**Quick Response Code**

**Abstract:** In this study, we analyzed the impact due to discharges of waste water from coffee washing stations on aquatic macro-invertebrates. Sampling has been made during coffee processing period and no coffee processing period. This study show that the macro-invertebrates increase during the coffee processing period and Hemiptera and Diptera individuals are most represented. There is variation of Hemiptera individuals which are less represented during coffee processing period but individuals increase during no coffee processing period. In opposite, Diptera individuals increase during coffee processing period than no coffee processing period. The study found that Diptera especially individuals belong to the chiromidae family are very abondunce during the coffee processing period. In the non-coffee processing period, we noticed that this taxon is less represented. These results show that individuals of the family of Chironomidae are bio-indicator of the pollution due to discharges of wastewater from coffee washing stations.

**Keywords:** *Chironomidae*, bio-indicator, pollution, coffee washing station.



## 1. INTRODUCTION

In Africa, aquatic ecosystems are subject to the disturbances of various kinds [1]. Despite their economic, social and ecological importance, African streams are degrading at an alarming rate [2]. This degradation leads to the disappearance of the aquatic macro-invertebrates which are generally used as bioindicators to assess the ecological quality of rivers [3]. Many studies have shown that the distribution of these organisms is associated to the abiotic conditions like water temperature, its content of oxygen and dissolved substances [4].

In Burundi, aquatic macro-invertebrates are almost unknown. The few data available are those on Lake Tanganyika which has interested scientists since the colonial period [5]. Little researches have already been carried out on the macro-invertebrates of the streams of Burundi, a country called thousand hills which are separated by streams. These streams are subject to many disruptions linked in particular to human activities on the hills generally on slopes subject to torrential rains and erosion. Beside these human disturbances, the pollution due to the spillage of organic matter does not seem to be a concern matter for famers. This is the case for coffee processing activities in Burundian coffee-growing regions, particularly the Kagoma coffee washing and drying station where we carried out this study.

This study investigates the effects of wastewater discharges from coffee washing and drying stations on aquatic macro-invertebrates. The main objective is to contribute to the protection of aquatic waters in Burundi by understanding the impact of organic pollution in the coffee processing chain on macro-invertebrates in streams.

This study shows the taxonomic indicators groups for pollution of organic discharges from coffee. Our hypothesis is that aquatic macro-invertebrates, like any form of aquatic life, would be qualitatively and quantitatively affected by pollution from wastewater discharges from coffee washing and drying stations and can be good indicators of the ecological condition of stream.

## 2. MATERIAL AND METHODS

### 2.1. Study zone

This study was carried out at the Kagoma coffee washing and drying station located in Ngozi Province, the north of Burundi. The wastewater from this station is discharged into a small stream called Samwe. This stream is surrounded by hills with coffee fields. In addition to using this water in the coffee processing, the water from this stream is also used by the local population for the irrigation of their rice fields. It is also used for an artisanal processed coffee or domestic use at upstream or downstream of coffee washing and drying station.

**2.2. Sampling and identification**

The sampling was carried out in 2020 in a period without a coffee campaign, three times in February and three times in October 2020. During the coffee campaign when the stream receives wastewater from coffee treatment, sampling was care out twice in March, twice in April and twice in June. Three sites were sampled taking into account their location in relation to the wastewater discharge point: the middle site corresponding to the wastewater discharge point, the upstream site being at the height of the point of discharge of this station and downstream located at the bottom of the ne place of discharge of wastewater from coffee washing and drying station.

The macro-invertebrates were identified using the keys of Leclercq and Michel-Marie S. [6], Moisan, J. [7]. The larvae and adults captured were determined to family level.

**2.3. Data analyzing**

In this study, we determined the relative abundance of each taxon (Pi = ni / N) where Pi is : relative abundance, ni: total number of individuals of the species, N: total number of individuals found in the site. The variability of taxonomic groups was determined by comparing the results obtained in the campaign period and outside the campaign. The evolution of the abundance of the most represented families was also determined using data for the months of February corresponding to the pre-campaign, March, April, June corresponding to the campaign and October where there is no activity related to the coffee treatment. Statistical analyses were made using Repeated measures One way Anova (GraphPad Prism 5).

## 3. RESULTS

**3.1. Taxonomic richness**

At the end of the sampling, 1371 individuals of macro-invertebrates were captured. During the no coffee processing period, we found 142 individuals downstream, 112 individuals in the middle and 118 upstream while during the coffee processing period, we found 492 individuals downstream, 279 individuals in the middle and 225 upstream. The comparative analysis of the three sites studied and the coffee period shows that there is significant difference between the no-coffee processing period and coffee processing period (Anova student-Newman-Keuls multiple comparisons test $p < 0.05$).

Taxonomical analyze in the three sites sampled show that all individuals belong to the phylum Arthropods, Molluscs and Annelids. Among the arthropods we have four orders: Coleoptera, Diptera, Hemiptera and Odonata, two orders of mollusks, Heterocardiums, Monotocardes and the order of oligochaetes in annelids. The individuals found are grouped into nine families which are Gerridae, Gyrinidae, Nepidae, Lestidae, Cystiscidae, Epitoniidae, Chironomidae, orthyncobdellidae and Haplatoxidae (Table 1).

**Table-1: Abundance of macro-invertebrates identified by site and by period: letters a,b,c indicate differences by Dunn's multiple comparisons tests following Kruskall wallis, same letters means there is no significant difference between the variables (ANOVA)**

| **Phylum** | **Orders** | **Family** | **No coffee processing period** | | | **coffee processing period** | | | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| | | | downstream | middle | upstream | downstream | middle | upstream | |
| | Coleoptera, | *Gerridae* | 20 | 22 | 25 | 31 | 41 | 35 | 174 |
| Arthropods | | | | | 28 | | 52 | 63 | |
| | | *Gyrinidae* | 19 | 11 | | 42 | | | 215 |
| | Diptera | *Chironomidae* | 29 | 13 | 6 | 382 | 147 | 76 | 653 |
| | | | | | | | 7 | 15 | |
| | Hemiptera | *Nepidae* | 16 | 30 | 19 | 20 | 20 | 18 | 107 |
| | | *Testidae* | | | | | | | |
| | Odonata | | 15 | 6 | 16 | 12 | | | 87 |
| Annelids | | *Orthyncobdellidae* | 14 | 8 | 4 | 3 | 0 | 1 | 30 |
| | oligochaetes | *Haplatoxidae* | 13 | 6 | 2 | | 1 | 0 | |
| | | | | | | 2 | | | 24 |
| | Heterocardium | *Cystiscidae* | 9 | 11 | 12 | 0 | 4 | 7 | 43 |
| Molluscs | Monotocarde | *Epitoniidae* | | 5 | 6 | | 7 | 10 | |
| | | | 7 | | | 3 | | | 38 |
| Total | **7** | **9** | **142$^a$** | **112$^a$** | **118$^a$** | **495$^b$** | **279$^c$** | **225$^c$** | **1371** |

**3.2. Variability of taxonomic groups**

**3.2.1. Variability of relative abundance of main orders**

The results show that the orders Hemiptera and Diptera are most represented compared to other orders (Figure 1). The relative abundance of Hemiptera is 10.6% downstream during the coffee processing period, but it is high (34.5%) outside the coffee processing period. The results for the relative abundance of Hemiptera in the middle corresponding to the wastewater discharge point is 20.6% during the campaign period but remains relatively high (43%) outside the coffee processing campaign. The relative abundance is low 22% in the coffee campaign period at upstream compared to the no-campaign period where the relative abundance is 39% (Figure 1). Statistical analysis showed us that there is a significant difference between the two periods (Kruskall wallis test, KW=62.05; p<0.001).

The results show that the relative abundance of Diptera is high during the period of coffee processing campaign compared to the period when there is no coffee processing at all sites studied. During the coffee processing campaign, the relative abundance of Diptera at downstream is 72.5% while it is 20.2% during no coffee processing period. In the middle corresponding to the wastewater used in the treatment of coffee, the relative abundance is 51.4% in the campaign period against 3.4% outside the campaign. Statistical analysis showed us that there is a significant difference between the two periods. Diptera in upstream, are abundant in the campaign period 33.7% compared to the period not corresponding to the coffee processing period 0.06%. Statistical analysis showed us that there is a significant difference between the two periods (Kruskall wallis test, KW=72.03; p<0.001) Figure 1.

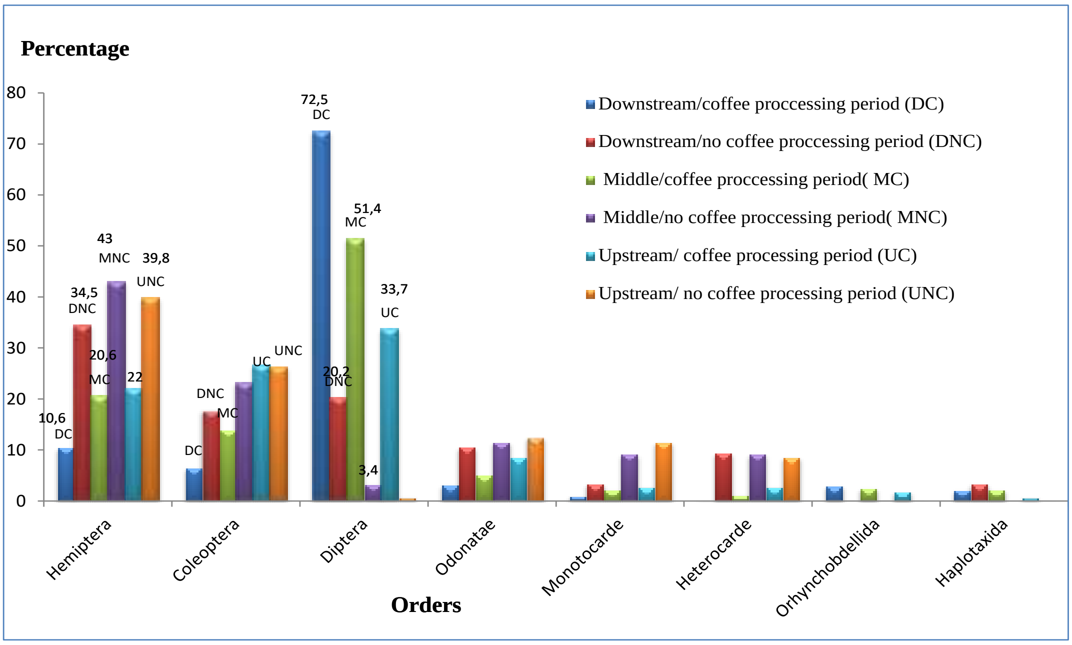


**Fig-**1: **Relative abundance of orders**

### 3.2.2. Variability of relative abundance of main families

The relative abundance of families shows that the Chironomidae family is more abundant during the coffee processing period with a raté of 79.6% at downstream, 64.8% in the middle and 45% at upstream from the coffee washing station. Relative abundance values remain low during no coffee processing period with relative abundance of 13.1% downstream, 2% in the middle, and 0.06% upstream of the coffee washing station (Figure 2). Statistical analysis showed us that there is a significant difference between the two periods (Kruskall wallis test, KW=54.75; p<0.001).

The results show that the relative abundance of Gerridae family at upstream is 3% in the coffee processing period but increases to 24.8% during no coffee processing period. In the middle, the relative abundance of gerridae is 6.6% in the coffee season but increases to 31.5% during no coffee processing period. The similary results are observed at downstream; the relative abundance of gerridae is 9.4% in the coffee season and reaches 26.3% during no coffee processing period (Figure 2).

By analyzing the relative abundance of the gyrinidae family, we observe the same trend where in the coffee season it is less abundant compared to the non-coffee season (Figure 2).

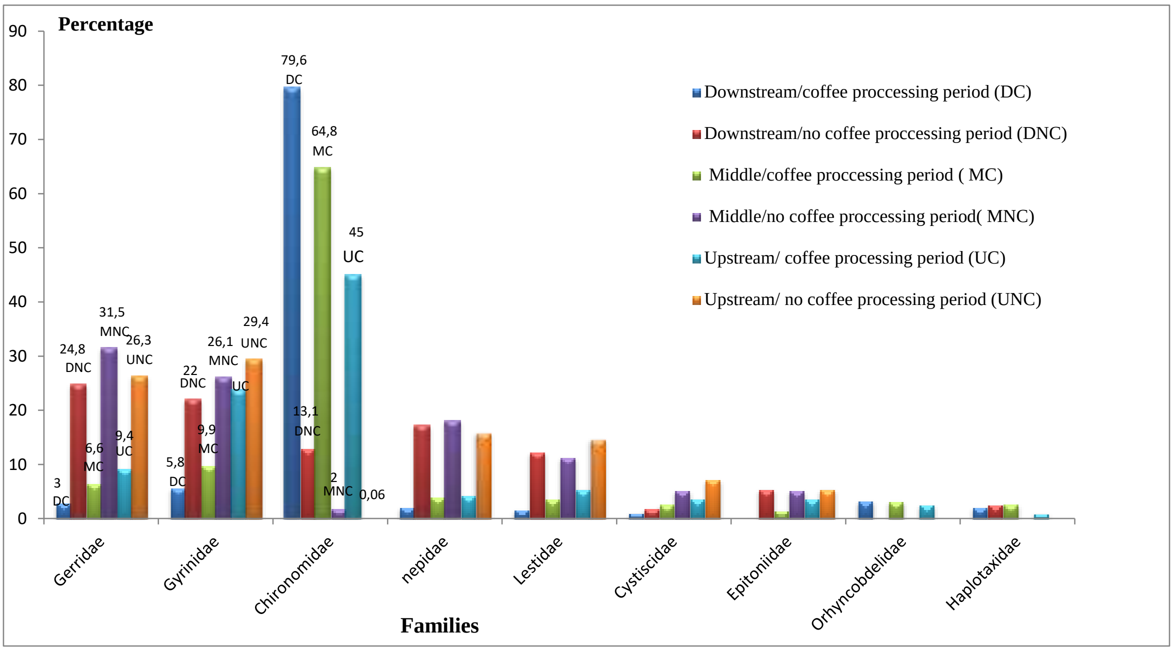


**Fig-2: Relative abundance of Families**

### 3.3. **Evolution of the Relative Abundance of the main families**

Two most represented families, Gerridae, and Chironomidae were followed outside the coffee processing period (February and October) and during coffee processing period (March, April May and June).

### 3. 3.1. Evolution of the abundance of Gerridae

Results show that individuals belonging to the Gerridae family at downstream of the coffee washing station, undergo a regressive evolution from February until April starting from 23.5% to 0%. From April, the individuals increase and their relative abundance increases from 0% to reach 43.1% in October (Figure 3).

The results of the middle corresponding to the discharge point of the water used in the treatment of coffee are similar to those found upstream. Indeed, the individuals of the Gerridae family undergo a regressive evolution from February to April, the relative abundance goes from 14.5% in February to reach 0%. We observed in April an increase in the number of individual until October (Figure 3).

At upstream, individuals belonging to the Gerridae family decline from 27.2% in February to 9.6% in April and then increase until October (24.1 %) (Figure 3).

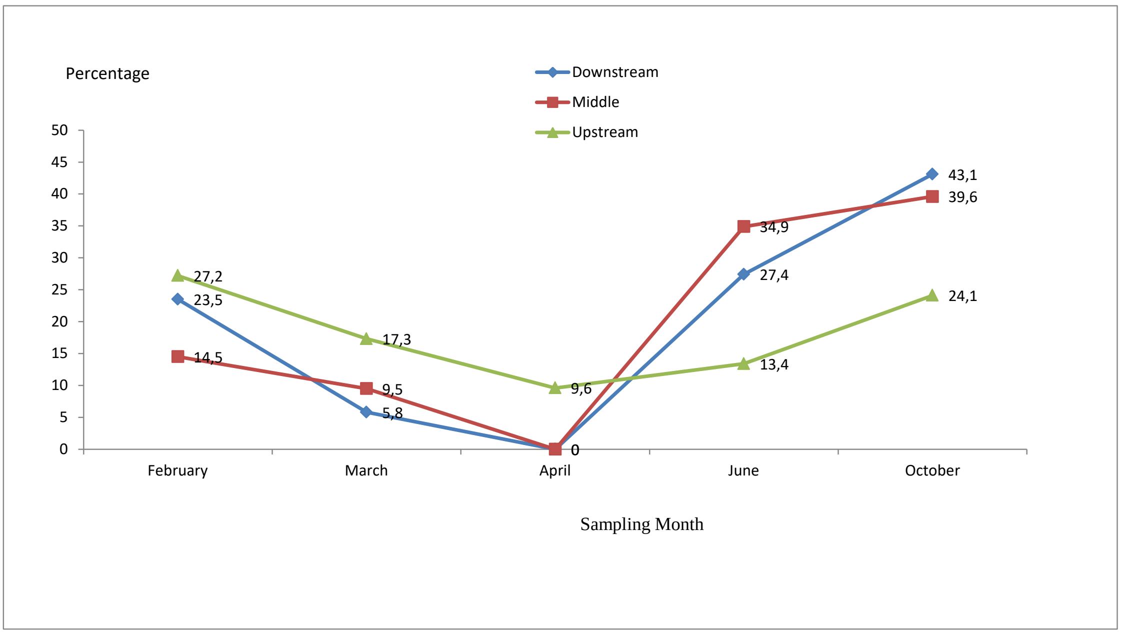


**Fig-3: Evolution of the abundance of Gerridae**

### 3.3.2. Evolution of the abundance of Chironomidae

The results of the evolution of the chironomidae at downstream begins to increase in February with a maximum in April to June (40.3%-45, 3%). Thereafter, we observe a regressive evolution until October when there are no Chiromidae individuals. In the middle zone, the evolution of the Chiromidae family shows their increase from March with the maximum in April to June 47.3% -51.2%. Since June, the results show a regressive evolution in October, there are no Chiromidae individuals.

At Upstream from the station, the evolutionary trend is observed with an increase in relative abundance observed from March to April (5.3%-28.1%). This evolution is followed by a decline in relative abundance from June (18.1%) to reach (0%) in October (Figure 4).

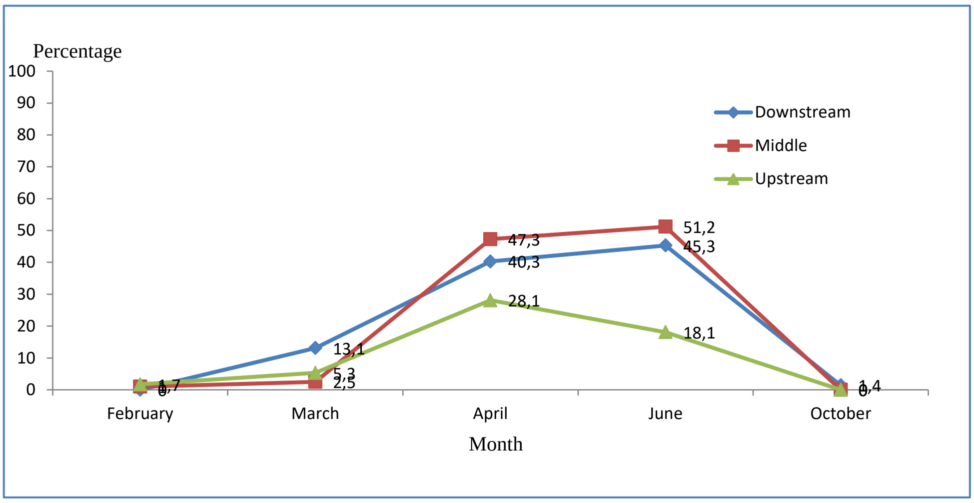


**Fig-4: Evolution of the abundance of Chironomidae**

## 4. DISCUSSION

### 4.1. Taxonomic richness

The purpose of this study was to analyze the impact of water used in the treatment of coffee on stream macro-invertebrates. We found that the relative abundance differs in the three sites studied; downstream, middle and upstream. The results show that the macro-invertebrates increase during the coffee processing period. These variations could be explained by some ecological factors of streams. Indeed, scientific researches have demonstrated that distribution of aquatic macro-invertebrates is influenced by a large number of environmental factors such as food availability [8]; hydrological conditions; Voelz *et al.* [9]; the composition of the substrate [10]; increased nutrient load; competition and predation [11]. In this case, nutrient load and food availability for macro-invertebrates from coffee processing are the main factors.

Hemiptera and Diptera individuals are most represented taxa in stream studied. Results show that Hemiptera individuals are less represented during coffee processing period but individuals increase during no coffee processing period. In opposite, Diptera individuals increase during coffee processing period than no coffee processing period. We found a significant difference between the no-coffee processing period and coffee processing period. This variation means that wastewater from coffee processing led to the disappearance of taxa sensitive to pollution, Hemiptera in this case and the proliferation of taxa resistant. Indeed, we found that Diptera are very abundant specially individuals belong to the chiromidae family compared to other taxonomic groups during the coffee processing period. In the non-coffee processing period, we noticed that this taxon is less represented. These results show a disturbance due to the presence of the coffee washing station.

### 4.2. Evolution of the Relative Abundance of families

In analyzing the evolution of two main taxa, two evolutionary trends caught our attention. On one hand, we observe that individuals of the Gerridae, and Chironomidae families increase with the coffee season, especially from April when the coffee activity is intense. The individuals belonging to these groups are therefore tolerant of the organic matter resulting from the processing of coffee. On other hand, we found that the Chiromidae individuals are less represented in February corresponding to no coffee processing period but undergo a gradual evolution during coffee processing period (March, April, May and June). Chiromidae individuals regress from this month and are no present in October. Several factors explain these results. Indeed, it has been demonstrated a strong correlation between the amount of organic matter and the number of individuals of Chiromidae [12]. For the Chiromidae, the organic matter resulting from the processing of coffee will serve as food, as Celeste Galizzi and her collaborators showed in 2012 [13]. From these results we can conclude that the Chironomidae family of the order Diptera is the indicator taxon for the pollution of wastewater from coffee processing wastes.

## REFERENCES


1. Tachet, P., Richoux, H., Bournaud, P., & Usseglio-Polatera, M. (2003). Invertébrés d'eau douce: Systématique, biologie, écologie; édition CNRS. *Paris, 588p*.
2. Thieme, M. L., Abell, R., Burgess, N., Lehner, B., Dinerstein, E., & Olson, D. (2005). *Freshwater ecoregions of Africa and Madagascar: a conservation assessment*. Island Press.
3. Jain, A., Singh, B. N., Singh, S. P., Singh, H. B., & Singh, S. (2010). Exploring biodiversity as bioindicators for water pollution. In *National Conference on Biodiversity, Development and Poverty Alleviation*.
4. Barbosa, F. A. R., & Callisto, M. (2000). Rapid assessment of water quality and diversity of benthic macroinvertebrates in the upper and middle Paraguay river using the Aqua-RAP approach. *Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen*, *27*(5), 2688-2692.
5. Allison, E., Bailey-Watts, A. E., Duck, R. W., Foxall, C., Patterson, G., & Petit, P. (1996). Report of the Lake Tanganyika Biodiversity Institution and Resources Assessment Mission to Tanzania, Zaire, and Zambia–8 August to 3 September 1996. Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika (UNDP/GEF/RAF/92/G32).
6. Leclercq Louis et Michel-Marie Solito de Solis. (2010). Clé simple de détermination des macroinvertébrés d'eau douce à l'usage de petit « gardien de rivière ». Station Scientifique des Hautes-Fagnes; Université de Liège
7. Moisan, J. (2010). *Guide d'identification des principaux macroinvertébrés benthiques d'eau douce du Québec, 2010 – Surveillance volontaire des cours d'eau peu profonds*, Direction du suivi de l'état de l'environnement, ministère du Développement durable, de l'Environnement et des Parcs, (version imprimée), 82.
8. Benoit-Chabot, V. (2014). *Les facteurs de sélection des bio-indicateurs de la qualité des écosystèmes aquatiques: élaboration d'un outil d'aide à la décision* (Doctoral dissertation, éditeur non identifié).
9. Voelz, N. J., Shieh, S. H., & Ward, J. V. (2000). Long-term monitoring of benthic macroinvertebrate community structure: a perspective from a Colorado river. *Aquatic Ecology*, *34*(3), 261-278.
10. Sandin, L., & Johnson, R. K. (2004). Local, landscape and regional factors structuring benthic macroinvertebrate assemblages in Swedish streams. *Landscape Ecology*, *19*(5), 501-514.
11. Céréghino, R., Ruggiero, A., Marty, P., & Angélibert, S. (2007). Biodiversity and distribution patterns of freshwater invertebrates in farm ponds of a south-western French agricultural landscape. In *Pond Conservation in Europe* (pp. 43-51). Springer, Dordrecht.
12. Moore, J. W. (1980). Factors influencing the composition, structure and density of a population of benthic invertebrates.
13. Galizzi, M. C., Zilli, F., & Marchese, M. (2012). Diet and functional feeding groups of Chironomidae (Diptera) in the Middle Paraná River floodplain (Argentina). *Iheringia. Série Zoologia*, *102*(2), 117-121.


**Cite This Article:** Dushimirimana Séverin & Rwasa Denis (2021). Impact of Wastewater from Coffee Washing Stations on Aquatic Invertebrates. *East African Scholars J Agri Life Sci*, *4*(1), 25-30.