SJIF Impact Factor: 5.464

WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

ISSN: 2457-0400
Volume: 4.
Issue: 4.
Page N. 66-70
Year: 2020

Original Article www.wjahr.com

MICROBIAL QUALITY CONTROL OF NIGER RIVER WATER IN URBAN AND PERI-URBAN AREAS OF BAMAKO

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Received date: 22 May 2020 **Revised date:** 12 June 2020 **Accepted date:** 02 July 2020

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ABSTRACT

Rivers are the most important freshwater resource for humans. However, because of the high density of populations, the growth and concentration of industrial centers on the banks of rivers favor the pollution of these rivers. Anything that presents a serious threat to human health. In Mali, the Bamako District is one of the major cities, whose water supply is mainly based on the Niger River. Unfortunately, in this city and its surroundings, this river receives a large amount of waste and untreated wastewater, which are likely to degrade the quality of its water, hence the need to regularly monitor the quality of this in the context of sustainable management of this resource. This study aimed to determine the water quality of the Niger River in Bamako and its immediate surroundings (Samaya, Ecole Normale Supérieure (ENSup), Martyrs Bridge and Moribabougou). Specifically, it was intended to (i) quantify the faecal coliforms contained in the water of the Niger River by the most probable number (MPN) method and (ii) determine the physicochemical parameters of the Niger River water, based on international standards established by ISO 7899-1. Results show that the water of the Niger River is heavily polluted in Bamako and in some areas of this city. Indeed, fecal coliforms have found in the water of the river, in particular at ENSup and the Martyrs' Bridge and the defined norm is very strongly exceeded several times. Similarly, nitrates (NO3-) have been encountered for a concentration exceeding the allowed standard.

KEYWORDS: Microbial quality, Niger River, water, Bamako, peri-urban.

INTRODUCTION

Rivers are the most important freshwater resource for humans. The economic and social development of a country is largely related to the availability and distribution of freshwater. In response to population growth and the growth and concentration of industrial centers, water quality problems have been intensified from year to year (Allushi et Hysko, 2010). Polluted waters are the most important vehicles for the spread of pathogens and the diseases they cause. Health can be compromised when pathogenic bacteria, viruses and parasites contaminate drinking water, either at the source or by infiltration of runoff within the canalized distribution system (WHO, 2007). In Mali, water resources have been under increasing threat from pollution in recent years (OMS, 2013). These threats are linked to rapid population growth and the establishment of human settlements without adequate health facilities (Satterthwaite, 2017). This is particularly prevalent in peri-urban centers, which surround the Bamako District. Many of these settlements have developed without adequate water supply and sanitation services. People living in these centers often use soiled surface water for irrigation, creating a situation that poses a serious health risk to the inhabitants (Busheé et al. 1998). In Bamako, the Niger River crosses fields and rural communities and receives several polluted water from pits of various kinds. Nevertheless, few studies have been done on the water quality of the Niger River in Bamako and surroundings. Regardless of the normal factors influencing water quality, human activities such as domestic and agricultural practices, the polluted water discharged by the several pits that lead to it continues to have a negative effect on the water quality of the Niger River. With water becoming an increasingly scarce commodity and the health of thousands of people linked

to it, it becomes imperative to undertake a quality assessment study for its sustainable management. Unfortunately, in Bamako and its surroundings, this river receives a large amount of waste and untreated wastewater, which are likely to degrade the quality of its water. That's why this project was initiated to assess the level of water pollution of the Niger River in Bamako. To assess the Niger River water pollution level in Bamako and its immediate surroundings, we will monitor the river water quality by defining the dynamic of the presence of the faecal coliforms in these waters as by Allushi et Hysko (2010).

MATERIAL AND METHODS

Sites

The monitored areas in the Niger River in Bamako are: 1. Samaya area, which is the entrance part of river in the city, 2 Ecole Normale Supérieure (ENSup) and Martyrs' Bridge areas, which are defined by the activities of the collectors and hotel along them, 3.Moribabougou, which represent the exit of this river from the city carring all the discharge.

Methods

Sampling

Forty eight (48) water samples were collected at a depth of 85 cm every 10 days for a period of 4 months in 2016 in the Niger River in Bamako and tested for chemical and microbiological contents. The sample bottles were labeled with date and sampling source. The samples are gathering in glass container sterilized in a sterilizer at 180°C temperature for 90 minutes. Samples were taken at a distance of 35-110 cm away from the river bank, and at a depth of 12-8 cm as indicated in Allushi et Hysko (2010). Sampling was done according to the method of Apha et al. (2012). As indicated by Britton (1999), the samples were placed in coolers and transported to the laboratory, where they were analyzed within 6 hours of collection.

Quantification of faecal coliforms (CF) contained in the water of the Niger River in Bamako and surroundings

The study is multiple fermentation tubes, MPN (Most Probable Number) by expressing the number of the bacteria by means of the index MPN, was the method used in this study (Allushi and Hysko, 2010). The number of bacteria is determined in base of the special tables based in the probability formulas. EC Broth Media was used. The cultivation was done in 44.5°C for 24 hour, after which was done the test of the confirmation in the tubes where it was confirmed the positive tubes for the production of the gas. The formation of the pink ring shows the presence of *Escherichia coli* (A.P.H.A.1995., Apha et al. 2012; Bernard *et.al* 1990).

Determination of physicochemical parameters

The physico-chemical parameters sought were temperature, pH, phosphorus, nitrates and nitrites. This research was based on international standards ISO 7899-1 (Miho et al., 2005). The temperature was measured in situ by thermometer and the pH was measured in the laboratory using a pH meter.

Collection and analysis of data

The data was collected during each of the four periods. The number of bacteria was based on special tables based on probability formulas according to Allushi and Hysko (2010).

RESULTS AND DISCUSSIONS

Results

Physico-chemical parameters of the Niger River water in Bamako and surroundings Good river water should be colorless

Color, odor and temperature

Out of the 48 samples: 32 are colorless, 11 light turbidity, 5 turbid color. The good river water should be colorless and the observation showed that the Niger River waters in Bamako are good in color. The river water should be odorless. 44 water samples are odorless**,** 4 water samples smelly. The observation showed that the Niger River waters in Bamako are good in odor.

Physico-chemical parameters

The results obtained from physic-chemical analysis of the Niger River water samples, based on CEE/CEEA/CE 78/659 analysis standards, are presented in Table 1.

Table 1: Physical and chemical parameters of the Niger River water at different sites.

Sites	Index	Unités	Moyennes
Samaya	Temp	^{o}C	26,50
ENSup	Temp	^{o}C	26,33
Pt Martyrs	Temp	^{o}C	27,17
Moribabougou	Temp	^{o}C	29,30
Samaya	pH	ph	7,50
ENSup	pH	ph	8,10
Pt Martyrs	pH	ph	7,73
Moribabougou	pH	ph	7,70
Samaya	NO2-	mg/l	0,05
ENSup	NO2-	mg/l	0,22
Pt Martyrs	NO2-	mg/l	0,013
Moribabougou	NO2-	mg/l	0,003
Samaya	NO3-	mg/l	0,01
ENSup	NO3-	mg/l	0,64
Pt Martyrs	NO3-	mg/l	0,79
Moribabougou	NO3-	mg/l	0,15
Samaya	PO4-	mg/l	0.45
ENSup	PO4-	mg/l	0
Pt Martyrs	PO4	mg/l	0
Moribabougou	PO4-	mg/l	0

From the results of the analysis of data presented in table 1, we noticed that: except for pH at ENSUP, the pH and P-PO4 are within the limit set by CEE. But, we didn't observe the same thing for nitrates (NO3-). The

level of nitrates is high, because of the discharges of urban waste in the river, in particular at ENSup and the the Martyrs' bridge, where the concentration of NO3 is high. The abnormal intensity or concentration of a physical and biological agents can degrade water quality of the water. The agent involved is called pollutant.

Quantity of faecal coliforms in the Niger River in Bamako and surroundings

The results obtained for the enumeration of faecal coliforms in the water of the Niger River at the different sites during the four months are presented in Table 2.

Table 2: Number of fecal coliforms in Samaya, ENSup, Pont des Marthyrs and Moribabougou.

Mois	Faecal coliforms (CFU/100 mL)			
	Samaya	ENSup	Martyrs's bridge	Moribabougou
Janvier	0	23000	2460	8400
Février	0	23800	2560	9500
Mars	20	33000	39200	2000
Avril	10	45600	52800	2850

According to the limits of faecal coliform for qualifying water quality presented in table 3, the results from table 1 data analysis showed that the faecal coliform concentration during the four-month sampling period of the year is very good in Samaya. The result observed in Samaya is different from those obtained in the other sampling sites, where the number of fecal coliforms reaches the maximum level allowed. In these sites, the water quality is very bad according the faecal coliform standards in table 3.

Table 3: Faecal Coliform (CF) Standards.

Faecal coliforms (CFU/100ml)	Quality of water			
	Very good	good	Bad	Very bad
	250-500	500-1000	1000-2000	>2000

The results presented in Table 4 indicate the quality of the river water in Bamako during the different months of the study.

Table 4: The level of faecal Coliforms pollution during four months.

Fecal coliforms	Months				Total
	January	February	March	April	
Very good	25%	25%	25%	25%	25%
Good	25%	25%	25%	0%	18,75
Bad	0%	0%	0%	0%	0%
Very bad	50%	50%	50%	75%	56,25%
Total	100%	100%	100%	100%	100%

As result of data analysis, 25% of the samples taken from January to April were very good and 25% of the samples taken from January to March were good. 50% samples taken from January to March, and were 75% of the samples taken in April were of very bad quality according to standards in table 3. The marked presence of fecal coliforms in the Niger River water in some study sites in all the water samples analyzed would be related to the multiple discharges of waste water and run off in the river. These waters are believed to contain faecal droppings.

Results presented in Table 5 indicate the quality of the river water at the different sampling sites.

Table 5: The level of faecal coliforms in the Niger River in Bamako related to monitored place.

Fecal coliforms	Place				Total
	Samaya	ENSup	Martyrs' bridge	Moribabougou	
Very good quality	100%	0%	0%	0%	25%
Good quality	0%	0%	0%	50%	12,5%
Bad quality	0%	0%	0%	25%	6,25%
Very bad quality	0%	100%	100%	25%	56,25%

From these results, it appears that the water of the Niger River is of very good quality in Samaya, 50% of good quality in Moribabougou, but of very poor quality at ENSup and the Martyrs' Bridge. The variation of the

concentration of faecal coliforms in the river water according to the sites and the periods shows that the pollution of this resource is observed differently in these sites and that this affection of the water of the river does not prevail to the same degrees according to the months of the year.

DISCUSSION

The main sources of pollution are of domestic and urban origin (wastewater, garbage dumps, fecal matter...), of agricultural origin (fertilizers, manures, pesticides), or of industrial origin (industrial discharges). In Bamako, pollution is mainly of domestic and urban origin, despite the existence of sources of agricultural and industrial pollution (Aboubacrine et al., 1991). Compared with the physicochemical parameters, based on the standard CEE / CEEA / CE 78/659, the Bratui Water Institute 2000 of Norvegia-NIVA, our results show that with the exception of ENSUP, the pH and P-PO4 are within the set limit, unlike nitrates (NO3-), for which the concentration exceeds the allowed standard. Many studies (Levis 1980, WHO 1978, Sibya 1980) have shown that the most common dissolved salts found in water are nitrogen compounds, nitrates (N03), nitrites (N02) and ammonium (NH4). According to ASSSCA (2011), the nitrate-nitrite standard dissolved in drinking water is 10 mg / l and water above 20 mg / l should simply not be consumed. The high level of nitrates in the river water at ENSup and the Pont des Martyrs could be related to discharges, especially from residual water resulting from upstream market gardening. It is known that such waters may contain residues of agricultural inputs. However, Yatabary (1994) noted that water pollution related to increased levels of nitrates can also come from other activities such as fishing with the use of toxic products to facilitate catching fish, artisanal dyeing, which uses very toxic products (caustic soda, sodium sulphide, dyes, etc.) or plantations and orchards, where are used plant protection products, urban solid and liquid wastes. The previous work by Sidibé (1992) on the physicochemical aspects of the pollution of the Niger River in Bamako showed values of 6.70 and 6.68 for the pH, 26.5 ° C and 29 ° C for temperature and traces for nitrates. A comparison of these results with those of our work shows a progressive alkalization of the river water and an increase of nitrates in this water.

The analyzed water samples appeared highly contaminated by faecal coliforms. Previous studies (Lewis et al., 1980, WHO, 1979) have shown that fecal matter contains on average 10^9 bacteria/g and 10^6 viruses/g belonging to 100 different types of virus. Bacteria unlike viruses, can multiply outside their host and their average infective dose is 10,000 units per liter or more, while that of viruses is less than 100. Septic tanks play an important role in this transmission.

The low concentration of these Enterobacteriaceae in the river water at Samaya could be explained by the low pressures on the river at this site. At Moribabougou, the pollution of the river water is a reality, but less pronounced compared to other sites (ENSup and Pont des Martyrs) where the water of the river is of very poor quality. This poor quality of the river's water is linked to the situation of these sites, because they are located in places where the river receives sewer pipes and more garbage. The increase in faecal coliforms in the river water in April can be explained by the high human influx around the river, because this month is one of the hot months and during which many people bathe in the river. At this time, the increase of fecal coliforms in the river water presents a serious public health problem. Indeed, all over the world, the many diseases that affect people are linked in part to the inadequate evacuation of domestic and industrial wastewater. These residual waters are becoming increasingly huge because of industrial development, population growth and the high density of urban areas. These waters are, in the absence of a treatment, a growing danger for human health and the natural environment because of their loads of toxic chemical substances and pathogenic micro-organisms (bacteria, viruses, parasites, etc.). They may pose a permanent threat to human and animal health (Ait et al., 2002, Talouizte et al., 2007) and WHO (2004) noted that 80% of the diseases that affect the planet's population are related to water pollution.

CONCLUSION

Our results showed that faecal coliforms are present in the Niger River in Bamako especially in the Martyrs' Bridge and ENSup where the defined standard is surpassed many times. The number of faecal coliforms is affected not only from the different parameters tested and shown in tables above but also from the different discharges that end up in this river affecting so the reduction of water quality and making it so a very serious problem for the health. In Bamako, the Niger River water is certainly polluted and if the process of the discharges in the river and no managing of the urban wastes will continued the situation for this waters and environment even more problematic in the future. So, it is useful to stop the dumping of waste and untreated sewage into the river.

Disclosure of conflict of interest

Authors declare that there is no conflict of interest that may have influenced the study.

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