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Microbiological characteristic of water resources in a fecal sludge dumping site in tropical area: The case of Nomayos, Cameroon

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ABSTRACT: The general objective of this research work was to assess the impact of fecal sludge discharge on the physicochemical and microbiological quality of water resources in the locality of Nomayos, a zone on the outskirts of the city of Yaoundé-Cameroon into which large quantities of raw fecal sludge from the city of Yaoundé are daily discharged. Field observations, household surveys and interviews with the emptying operators was used. Quantification and characterization of the fecal sludge collected at the discharge site and laboratory analysis of 08 groundwater samples and 06 water samples taken from the Avo'o watercourse were conducted. The average fecal coliform contents of irrigation points for vegetable crops ranged from 1012 ± 613 - 32 x 10^3 ± 12.80 x 10^2 CFU /100 mL for S0, S1, S2, and S3. The mean fecal streptococcal values for the same points are 264.20 ± 189.52 - 15.40 x 10^2 ± 14.20 x 10^2 CFU /100 mL for S0, S1, S2, S3. The average helminth egg concentrations for the different sites show that the helminth egg concentrations moved linearly to Site 3 where they reach their optimum. Then they decrease to P8 and increase progessively to P9. Sites S1, S2, S3, P8 and P9 have very high mean helminth egg concentrations of 42.33, 54.95, 71.33, 20.52 and 26.33 eggs/L respectively, compared to S0 which is 6.33. Groundwater analysis showed high concentrations of fecal pollution control germs, notably fecal coliforms and fecal streptococci.
Measures for the control and protection of water resources therefore deserve to be taken in this locality for the preservation of water resources and the health of the population.

KEYWORDS: Fecal sludge, surface water, groundwater, microbiology, parasites, Nomayos-Yaoundé.

1 INTRODUCTION

Effective management of fecal sludge is a challenge that public authorities, private enterprises, and households have to meet in most cities of the world. In fact, 2.3billion people in the world lack access to basic sanitation services, such as toilets or latrines [1], [2]. Let us recall that [3] define fecal sludge as the combination of excreta (feces and urine) and toilet washing water with or without greywater from house units. This mixture most be adequately collected, carefully stored and safely transported to appropriate sites in order to avoid undesirable effects on human and environmental health. In fact, managing fecal sludge means their safe storage in the households' compounds and public sanitation facilities, emptying the pits and transportation of fecal sludge to the treatment site for reuse or disposal [4]. As [5] noticed, if these three aspects are not dealt properly, it is not possible to get the full benefits of achieving increased access to safe sanitation.

Towns in developing countries keep facing tremendous problems of solid and liquid wastes sanitation [6], [7]. Around 50 percent of the sub-Saharan African population do not have access to improved sanitation facilities [8]. The problem becomes more cumbersome with regard to the high population growth rate and rapid spatial extension of African cities. Newcomers contribute extensively to the development of unorganized quarters in the absence of an urban master plan and characterized by a lack of domestic grey water sewer networks [9]. On-site sanitation systems like septic tanks or pits latrines that prevail in these settings need regular draining, however, the FS collected is dumped everywhere and even near houses, in streams, and on virgin lands. Whereas, inadequate disposal of fecal sludge could be the origin of infectious diseases that neighboring populations suffer from [10], [11], [12].

Cameroonian cities are characterized by the absence of real policy on sanitation. Sludge management as currently practiced is limited to the drain of health facilities, provided by municipal or private companies and does not provide treatment system. In

Yaounde, the fecal sludge collected through the city is dumped in a landfill, to Nomayos. Unfortunately, this uncontrolled discharge is adjacent a river, the Avo'o whose waters are used for irrigation of vegetable crops a revenue generating activity is widespread in this area. The objective of this study is to make a water and to assess the contamination of water resources in Nomayos.

2 Material And Methods

2.1 Presentation Of The Study Site

The study site is located in Nomayos, a locality situated at 20 km away from Yaoundé, the capital city of Cameroon. The zone serves as an indiscriminate dumping site for sludge collected by vacuum trucks from onsite sanitations in Yaoundé (Fig. 1). Sludge is discharged daily into the few wells available (Fig. 1a) or directly on the soils surface (Fig. 1b). The sludge deposited then leaches into rivers near the area of discharge where farmers coincidentally collect water for irrigation of their crops (mostly vegetables) [13]. The work was carried out along the borders of two tributaries of river Avo'o. The site has a surface area of about 300 m^2 and receives approximately 1350 m^3 of untreated fecal sludge per week [14].

2.2 Methodology

2.2.1 State Of Fecal Sludge Duping Activities At Nomayos

During one week, data were collected at Nomayos dumping site, in other to evaluate the fecal sludge quality dumped, the number of trucks involved in the activity, the truck capacity, the frequency of each different trucks capacity in the site and the social profile of each operators. After this, raw fecal from each trucks, water samples from Avo'o river and ground water were sampled in the study area for lab analysis.

2.2.2 Sampling Techniques

Triplicate sampling was conducted which consisted of collecting surface and ground water samples. Surface water sample where collected at six points i.e. 130 m from the fecal sludge discharged point (P11), 380 m up to the fecal sludge discharged point (P 9), 400 m of the first discharged point (P8), 810 m down of the fecal sludge discharged point (P12), 1890 m up to the fecal sludge discharged point (P13), the control which was 3 km from the fecal sludge discharged point. While groundwater was collected from 7 points as shown table 1 below. All the bottles were previously washed with detergent and further rinsed with deionized water prior to usage. Finally, before sampling was done, the bottles were rinsed with the sample water three times at the point of collection. Samples for bacteriological analyses were kept in well capped glass bottles that have been sterilized in an autoclave for 15 minutes at 121ºC. For surface water the bottles were held in the middle and immersed about 10-20 cm in water against flow [15].

Table 1. Description of sampling point location

Type of water resources	Sampling points	Location of the sapling point
Surface water	P11	Located at 130 m from the fecal sludge discharged point
	P9	Located at 380 m up to the fecal sludge discharged point
	P8	Located down at 400 m of the first discharged point
	P12	Located 810 m down of the fecal sludge discharged point
	P13	Located at 1890 m up to the fecal sludge discharged point of the current landfill and 700 m from the first sludge discharge point
	P14	control point located 3 km from the sludge dump site
Ground water	P1	borehole located at 890 m from the sewage sludge disposal site
	P2	control borehole, located 4 km from the landfill site
	P3	well located 300 m from the first discharge point;
	P4	well located 1 km upstream of the fecal sludge disposal site;
	P5	shaft located 690 m downstream of the fecal sludge disposal site;
	P6	spring located 2020 m from the fecal sludge disposal site;
	P7	control spring located in Mbankomo

2.2.3 FECAL SLUDGE AND WATER ANALYSIS

The samples collected were analyzed in the laboratory for both physicochemical and bacteriological analysis. pH, Temperature (T°), were measured using pH meter (Hach HQ11d). Electrical Conductivity (EC), Salinity, Total Dissolve Solids (TDS) were measured using conductimeter (Hach (HQ14d)., Nitrates (NO_3^-), were measured using spectrophotometer (Hach DR/3900). This were determined using standard protocols [15].

2.2.4 MICROBIOLOGICAL TESTS

Samples of fecal sludge water from river Avo'o and lettuce irrigated with water from this river were collected for different microbiological and parasitological analysis. For this, four (04) points (S0: control site located at Mbankomo, 3 km away from the fecal sludge discharge area; S1: site 1 located 810 m before the fecal sludge discharge area; S2: site 2 located 100 m near the fecal sludge discharge area and S3: site 3 located 350 m after the fecal sludge discharge area) were mapped out for sampling. The microbiological analysis involved mostly the determination of the presence of fecal streptococci and coliforms using the membrane filtration protocol. Parasitological analysis to determine the presence of helminth eggs were carried out using the protocol described by [15].

2.2.5 DATA ANALYSIS

The ANOVA test was conducted to determine the effects of different treatments applied on the bacteriological, parasitological and morphological parameters of *Lactuca sativa L*. Specifically, a two way ANOVA was used to determine any correlations and interactions between the different sites (S0, S1, S2 and S3) and the different growth parameters. On the other hand, a one way ANOVA was used to determine the means of the different microbiological and parasitological parameters.

3 RESULTS AND DISCUSSION

3.1 ACTUAL STATE OF THE NOMAYOS DUMPING SITE

3.1.1 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF SURVEYED HOUSEHOLDS

The socio-demographic characteristics of the households studied are shown in Table 2. The vast majority of households are built in hard and semi-hard bricks (82.4 %) against 14.8 % of households that are made of planks and 3 % of clay bricks. 17.34 % of the households surveyed are of high standing, 42.29 % of medium standing and 38.28 % of low standing. Sample selection was carried out by gender and by age groups [0-5 years], [10-19], [20-29], [30-39], [40-49] and ≥ 50 (Fig. 86). It emerges that in Nomayos, the age groups of individuals are characterized by the representation of children under 5 years old and the elderly. The female sex (51%) is dominant and reflects national proportions (52% of women in Cameroon according to INS, 2004).

Table 2. Socio-demographic characteristics of households

Parameters	Variables	Frequencies	Percentages
Characteristic of the building	Hard or semi-hard with barrier	270	42.3
	Hard or semi-hard without barrier	256	40.1
	Plates	94	14.8
	ground	2	3
	Others	1	1
Gender of head of household	Male	280	49
	Female	292	51
Ages of household residents	[0-5 years] [10-19 years] [20-29 years] [30-39 years] [40-49 years] and ≥ 50		13 4 6 11 53 13

3.1.2 State Of Dumping Site At Nomayos

This study revealed that the Nomayos dumping site is regularly visited by dump trucks that not only degrade the access roads, but also degrade the site's environment. Indeed, it has been observed that some of the dumpers who dump the fecal sludge in the fields or on the access road to the site are uncivilized which confirms the study of [16]. In addition, there is a real increasing degradation of the environment (Figure 1).

Solid waste such as sanitary textiles, plastic waste, condoms etc. were also found in the fecal sludge, a situation which is mostly observed in developing countries where toilet users dump these wastes into their toilets as disposal means [17].

Emptying at the entrance of the site

Path degraded by trucks

Emptying in the field next to the dump site

Mixed waste observed on the site

Emptying on the site

Degraded environment

Fig. 1. The physical condition of the site: degraded environment and trucks in a state of emptying

3.1.3 Perception And Acceptability Of The Disposal Site By The Population

The populations in the study area perceive the disposal site as a source of enrichment (51%), disease (37%), social detour (7%) and insecurity (3%). Regarding the acceptability of the site's presence, more than half of the population are in favor of the site's existence (52%), (40%) are against it and (8%) have no opinion.

The acceptability was mostly by those who practice agriculture around the site as these dumping increases their output [14]. In a similar study conducted by [18] on community fecal management strategies and perceptions on sludge use in agriculture about 60% of the surveyed population are ready to use treated sludge for agriculture.

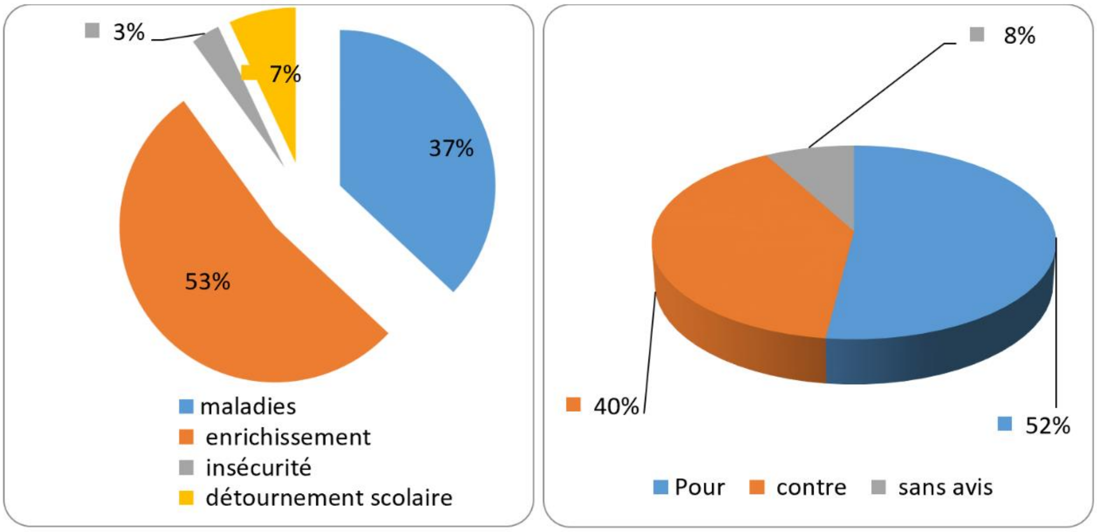

Fig. 2. Perception (left) and acceptability (right) of the disposal site by the population

3.1.4 Quantities Of Fecal Sludge Dumped At The Nomayos Disposal Site

A total of 25 vacuum trucks were identified as operating at the Nomayos disposal site, with capacities ranging from 7m³ to 17m³ (Table 3). The majority of these trucks have capacities between 10 and 14m³ (15 and 6 trucks respectively). In addition, two trucks have a capacity of 17m³. Most of the companies do not have statistical data sheets to quantify the sludge collected. However, the surveys showed that each truck makes at least one trip per day during the 6 (six) working days of the week. On this basis, a minimum of 3020 m³ of sludge is dumped per month or 755 m³ per week on the site. Similar results were obtained by [14] who obtained 140.97 m³/d on the same site. The 10 m³ trucks make the largest number of trips to the site, followed by the 14 m³ trucks.

As a result of this anarchic dumping, eutrophication of water bodies and soil pollution may arise due to oxygen depletion. Another serious issue is that some trucks drivers collect and dump in this area sludge mixed with engine oil and probably some unidentified pollutants which can contain heavy metals and polycyclic aromatic hydrocarbons [14], [16].

Table 3. Estimated quantity of fecal sludge per month and per week in Yaoundé

Truck capacity	Number of trucks	Number of trips per week	Number of trips per month	Quantities estimated by Week (m³)	Quantities estimated monthly (m³)
7m³		7	28	49	196
8m³		0	1	2	8
9m³		1	2	5	18
10 m³	15	34	134	335	1340
12 m³		0	1	20	12
13 m³		2	6	3	78
14 m³	06	22	88	308	1232
17m³	02	2	8	34	136
Total	25	67	268	755 m	3020

3.2 Physicochemical And Microbiological Composition Of Raw Fecal Sludge Dumped In Nomayos

3.2.1 Physicochemical Composition Of Raw Fecal Sludge Dumped In Nomayos

The fecal sludge analyzed showed high concentrations of physicochemical pollutants (table 4). These sledges, although close to neutrality, have a slightly acidic character with an average pH of 6.48 ± 5.40 within optimal ranges (6.5 – 9) required for biological degradation of organic matter by microorganisms [19] and high salinity (0.35 ± 0.23). Also excessive electrical conductivity (5567.20 ± 4860.57), high concentrations of nitrate and ammonium ions 578.60 ± 400.97 mg/l and 373.86 ± 380.86 mg/l respectively, the high values of nitrogen ammonia might result from the ammonification and mineralization of organic nitrogen. Loads of organic pollutants, especially COD and BOD_5, are excessive compared to the permissible limit values for the receiving environments. These concentrations are between 1200 and 49433 mg/l for COD and between 6700 and 19720 mg/l for BOD5.

One of the critical and most important parametric indicators in fecal sludge characterization is the COD to BOD ratio as it forms the basis of whether it could be biologically treatable or not. The ratio obtained in this study was 2.08 this shows that the FS has slightly low biodegradability potential. This is also consistent with the work of [20] indicates that low biodegradability is characterized by COD: BOD ratio and attributes the value of 26 to FS that is stored for long periods of time or due to the presence of inorganic pollutants.

Table 4. Physicochemical composition of raw fecal sludge dumped in Nomayos

Variables Parameters	Mean	standard deviation	minimum	maximum	WHO standards
CND (µS/cm)	5567.20	4860.57	1443.00	11540.00	
TDS (mg/l)	2984.60	2695.27	719.00	6350.00	
PH	6.48	0.63	5.40	6.93	
Sal (%)	0.32	0.23	0.07	0.66	
T (°C)	27.84	1.18	25.60	29.00	
NO_3^- (mg/l)	578.60	400.97	260.00	1250.00	
NH_4^+ (mg/l)	373.86	380.86	131.80	1050.00	
Cl^- (mg/l)	657.40	818.73	230.00	2117.00	
COD (mg/l)	31433	8500	1200	49433	
BOD_5 (mg/l)	15135	3400	6700	19720	
COD/BOD_5	2.08				

3.2.2 MICROBIOLOGICAL INDICATOR AND HELMINTHES EGGS IN RAW FECAL SLUDGE (N=XX)

The concentrations of helminth eggs in the sludge analyzed are very high and comparable to those of sludge from tropical countries, and therefore very high compared to those of wastewater in which the parasitic germ contents are generally of the order of 30 - 2000 germs/L [20]. The presence of these parasitic germs in the sewage sludge thus reflects a greater likelihood of gastrointestinal diseases as well as viral infections among the population of the city of Yaoundé.

Table 5. Microbiological indicator and helminthes eggs in raw fecal sludge (n=xx)

Species	Means	SD	Minimum	Maximum
CF (UFC/100 ml)	2286000.00	2546503.49	240000.00	5500000.00
SF (UFC/100ml)	1068000.00	1646244.21	100000	4000000.00
Ascaris sp	2176	502	1400	2800
Enterobius sp	649	311	217	1600
Ankylostoma sp	469	393	0	1200
Trichuris sp	218	109	0	867
Schistosomia sp	54	187	0	650
Teania sp	36	13	0	433

3.3 SURFACE WATER CHARACTERISTICS

3.3.1 BACTERIOLOGICAL CHARACTERISTICS OF SURFACE WATER

The average fecal coliform (FC) contents of irrigation points for vegetable crops are in the order of $14 \times 10^2 \pm 11.60 \times 10^2$ CFU /100 mL for S1, $32 \times 10^3 \pm 12.80 \times 10^2$ CFU /100 mL for S2, $32 \times 10^3 \pm 12, 80 \times 10^2$ CFU /100 mL and 1012 ± 613 CFU /100 mL for S0. These values are higher than for S0. The mean fecal streptococcal values for the same points are 370 ± 1132 CFU/100 mL for S1, 14.80×10^2 CFU/100 mL for S2, $15.40 \times 10^2 \pm 14.20 \times 10^2$ for S3 and 264.20 ± 189.52 for S0. (Table 6).

Fecal contamination in irrigation water may lead to the transfer of pathogens from fecal material to soil and also vegetables grown in these sites. A unified standard for surface irrigation water is hampered by types of water sources, land use, and crops, however [21] recommend a value less than 1000 CFU/100ml [22]. observed fecal contamination of vegetables in markets and supermarkets sold in the Philippines. It is possible that such contamination may be introduced to produce through poor quality, irrigation water and by transmission of fecal pathogens from irrigated soils; as such same observations can be deduced in this study.

For bathing and washing points, these values are respectively of the order of: 3 x 103 ± 1078 CFU/100 mL and 59.22 x 103 ± 57.20 x 103 for CF and 1060 ± 653 CFU/100 mL and 13114 ± 12971 CFU/100 mL for fecal streptococci.

Table 6. Mean table with standard deviation of bacteriological parameters of market gardening sites and bathing points at the threshold α = 5%

Sites	Bacteriological parameters		
	FC (CFU/100 mL)	FS (CFU/100 mL)	[22] (irrigation water)
S0	1012 ± 613	264.20 ± 189,52	< 1000 CFU/100 mL /
S1	$14 \times 10^2 \pm 11.60 \times 10^2$	370 ± 1132	< 1000 CFU/100 mL
S2	$32 \times 10^3 \pm 12.80 \times 10^2$	$14.80 \times 10^2 \pm 12 \times 10^2$	< 1000 CFU/100 mL
S3	$45.80 \times 10^3 \pm 22.80 \times 10^2$	$15.40 \times 10^2 \pm 14.20 \times 10^2$	< 1000 CFU/100 mL
P8	$3 \times 10^3 \pm 1078$	1060 ± 653	-
P9	$59.22 \times 10^3 \pm 57.20 \times 10^3$	13114 ± 12971	-

From the analysis of the classification table of the different points, it appears that points S2, S3, P8 and P9 belong to water class B which are moderately polluted compared to sites S0 and S1 which belong to water class C which are slightly polluted (table 7).

Table 7. Classification of the different points sampled according to their coliform load

Points	FC (CFU/100 mL)	FS (CFU/100 mL)	classification	zone
-	10^5-10^7	10^6	highly polluted	A
S0	10^1	10^1	slightly polluted	C
S1	10^2	10^1	slightly polluted	C
S2	10^3	10^3	moderately polluted	B
S3	10^3	10^3	moderately polluted	B
P8	10^3	10^3	moderately polluted	B
P9	10^3	10^3	moderately polluted	B

3.3.2 Helminth Egg Concentration In Sampling Points

The average helminth egg concentrations for the different sites are presented (Fig 2), with the helminth egg concentrations moving linearly to Site 3 where they reach their optimum. Then they decrease to P8 and increase progessively to P9. Sites S1, S2, S3, P8 and P9 have very high mean helminth egg concentrations of 42.33, 54.95, 71.33, 20.52 and 26.33 eggs/L respectively, compared to S0 which is 6.33. The average helminth egg concentration at these sites is very high which is same as other studies [23]. These concentrations are 3 to 9 times higher than that of S0. It appears that the concentration gradient is increasing according to S3 > S2 > S1 > P9 > P8 > S0. Due to the high helminth egg concentrations in positive samples analysed, the need for proper health and environmental protection measures has to be stressed to prevent helminthic disease transmission due to untreated sludge discharge into the environment after pit latrine emptying or via direct agricultural use [23].

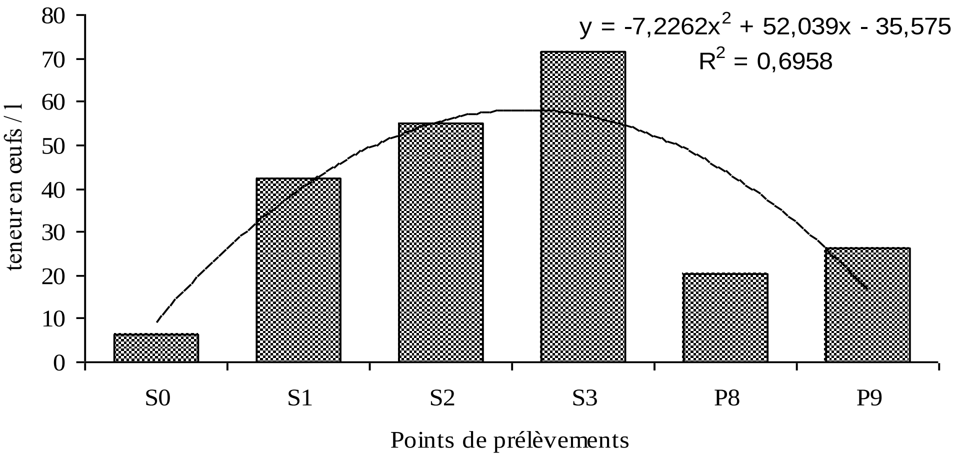

Fig. 3. Helminth egg content according to sampling points

3.4 Groundwater Characteristics

3.4.1 Bacteriological Variables Of Groundwater At The Threshold A = 5 %

All of the groundwater analyzed in the Nomayos locality showed high concentrations of fecal pollution control germs, notably fecal coliforms (FC) and fecal streptococci (FS). These concentrations ranged from 16.60 ± 9.45 to 6430 ± 3145 CFU/100ml for FC and from 4.20 ± 20 to 6430 ± 3145 CFU/100ml for FS. They are also very high and well above the guide values of the World Health Organization, which recommends a total absence of germs in groundwater, particularly for consumables or domestic use. The presence of germs indicative of fecal contamination in this groundwater would be the result of the uncontrolled and uncontrolled discharge of fecal sludge in this locality. The points closest to the landfill are, moreover, the points with the highest concentrations of these germs.

Table 8. Mean fecal concentration of sampled points

Parameters Sampling points	FC (CFU/100 ml)	FS (CFU/100 ml)
P1 (dump site location)	101.40 ± 72.49	9.40 ± 8.67
P2	16. 60 ± 9.45	4.20 ± 20
P3	373.00 ± 234.43	77.00 ± 34.69
P4	193.20 ± 78.09	54.80 ± 17.29
P5	972.00 ±772.85	211.80 ± 9.43
P6	1922 ± 32. 00	532.00 ± 492.26
P7	6430 ± 3145	6430 ± 3145
WHO standard	00/100 ml	00 UFC /100 ml

3.4.2 Helminth Eggs Concentration Of Groundwater

The same observations can be made with helminth eggs that were present in all the water points analyzed, with higher or lower concentrations depending on the groundwater point considered or on the helminth egg species identified. *Ascaris sp* eggs had higher concentrations overall, followed by *Enterobius sp*, hookworm sp and *tricuris sp*. Species of the genus *taenia* were almost absent in all samples, with the exception of point P3 which had a concentration of 6.66 ± 2.50 of *Taenia sp*.

Table 9. Mean helminth egg levels in well and spring water

Points	*Ascaris* sp	*Enterobius* sp	*Ankylostoma* sp	*Trichuris* sp	*Taenia* sp
P1	114.16 ± 60.67	29.16 ± 15,16	27.5 ± 19.09	17.50 ± 9.79	0.00 ± 0.00
P2	118.75 ± 46.32	28.33 ± 18	16.66 ± 11.54	11.33 ± 10.20	0.00 ± 0.00
P3	190 ± 79.72	75.00 ± 37.25	38.33 ± 19.25	21,66 ± 17.92	6.66 ± 2.50
P4	11.30 ± 8.40	5.02 ± 1.12	1.16 ± 0.80	8.32 ± 9.30	0.00 ± 0.00
P5	20.22 ± 11.92	9.05 ± 3.50	1.33 ± 0.50	3.00 ± 2.16	0.50 ± 1.30

The most prevalent helminth eggs recognized is *A. lumbricoides*, same as with data reported in the literature stating that Ascaris is universally one of the most frequent causes of helminthic infections [24]. Besides, *Ascaris* eggs are also characterized by their high resistance to environmental conditions, such as desiccation pH, temperature etc [25], [26]. As the observed parasite egg concentrations in samples were higher than the limit recommended in the [27] guidelines for safe use of excreta in agriculture (<1 egg/g of DM).

[28] pointed out that the persistence of helminth eggs in the environment is the most important risk factor for disease transmission. To prevent disease transmission, it is necessary to apply particular interventions for safe disposal and storage of excreta

3.5 CORRELATION

The correlation matrix (Table 10) below shows that there is a link between the physico-chemical and bacteriological pollutants in sludge and those in water. It therefore appears that the fecal sludge dump is at the origin of the contamination of these environmental components.

Table 10. Pearson correlation matrix between the physico-chemical and bacteriological parameters of fecal sludge and those of some environmental components

	CND	TDS	Sal	T (°C)	PH	NH_4^+	NO_3^-	Cl^-	FC	FS
CND	1									
TDS	1,000**	1								
Sal	0,123	0,119	1							
T (°C)	0.063	0.064	-0,264	1						
PH	0.307	0.306	0.270	0.432	1					
NH_4^+	1.000**	1.000**	0.122	0.063	0.303	1				
NO_3^-	1.000**	1,000**	0.128	0.062	0.304	1.000**	1			
Cl^-	1.000**	1.000**	0.119	0.076	0.305	1.000**	1.000**	1		
FC	1.000**	1.000**	0.119	0,055	0.305	1.000**	1.000**	0.999**	1	
FS	1,000**	1.000**	0.121	0.059	0.303	1.000**	1.000**	1.000**	1.000**	1

*** Significant correction at the threshold of 0.01 (2-tailed).*

The parasites identified in the waters sampled at S0, S1, S2, S3, P8 and P9 belong mainly to the nematode classes and are represented by the species: *Ascaris sp*, *Enterobius sp, Ankylostoma sp, Trichuris sp* and *Schistosoma sp*. In terms of frequency of species occurrence, regardless of the source of sampling, eggs of *Ascaris* sp, *Enterobius* sp*, Ankylostoma* sp *and Trichuris* sp*.* are most present in each sampling point respectively. Independently of of the wateer sample analysed the parasites identified followed the same order of concentration with highest value eggs of *Ascaris* sp, *Enterobius* sp*, Ankylostoma* sp *and Trichuris* sp*.* respectively.

Diseases caused by bacteria, viruses and protozoa are the most common health hazards associated with un-treated drinking and recreational waters. The main sources of these microbial contaminants in wastewater are human and animal wastes [27]. These contain a wide variety of viruses, bacteria, and protozoa that may get washed into drinking water supplies or receiving water bodies [29]. Microbial pathogens are considered to be critical factors contributing to numerous waterborne outbreaks. Many microbial pathogens in wastewater can cause chronic diseases with costly long-term effects, such as degenerative heart disease and stomach ulcer. The density and diversity of these pollutants can vary depending on the intensity and prevalence of infection. The types and numbers of pathogens in sewage will differ depending on the incidence of disease and carrier states in the contributing human and animal populations and the seasonality of infections. Hence, numbers will vary greatly across different parts of the world and times of year.

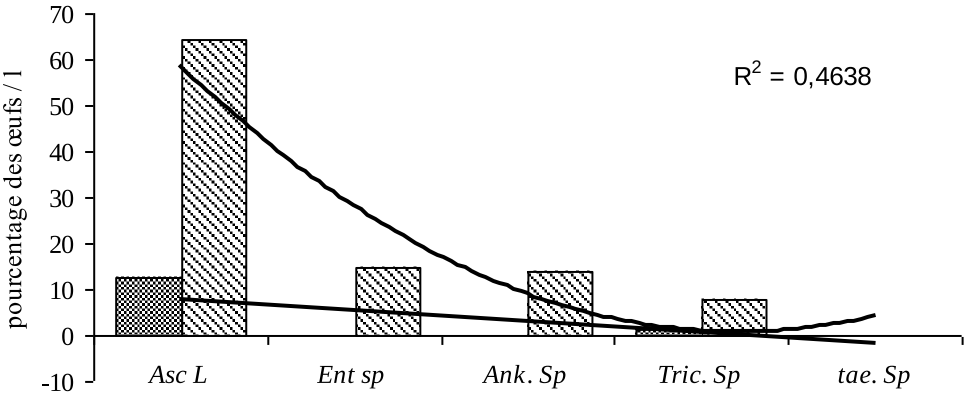

Fig. 4. Distribution of helminth eggs in irrigation water

4 CONCLUSION

Nomayos have been subjected to various contaminated materials capable of initiating the impairment of water resources quality. The present study of physical, chemical, microbiological and parasitological characteristics of the ground and surface water provided a considerable insight into the quality of each resources. The increasing concentration of different pollutant, notably physicochemical, microbiological and parasitological generated from raw fecal sludge, and their subsequent release to surrounding raise a wide spread and increasing public concern over the use of the surface and ground water. The present study shows that the surface and ground waters are highly polluted with nitrates, chlorides and sulphates. Similarly, the FC, FS and helminth eggs values are not within the permissible limits given by WHO. There is an urgent need to arrest the problem of pollution in Nomayos to protect the water body, maintain its water quality and enhance its use for domestic purposes. To this end, the Establishment of operational team to provide local and regional planning and environmental management authorities with data is necessary. The team will check for compliance with guidelines and prescribe standards for effective water usage and environmental protection measures. There is need for enactment of law that will prohibit fecal sludge from discharging harmful physicochemical, microbial and parasite waste into the nature without treatment.

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