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EFFECT OF LANDFILL OF UNTREATED AND UNCONTROLLED WASTE DISCHARGES ON WATER QUALITY AND HUMAN HEATH IN THE MUNICIPALITIES OF ABOMEY-CALAVI AND GODOMEY IN BENIN

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Abstract

Uncontrolled waste discharges increase significantly in the districts of Abomey and Godomey of Benin. Wastewater and rainwater leach these garbage discharges and produce leachate seeping into the soil and contaminate groundwater. To assess the pollution of groundwater from garbage discharges in these districts, the physico-chemical analysis were carried out on 21 samples of water taken from wells near to garbage discharges and 21 sample from wells in a control area located very far from the garbage discharges (about 7 km from the garbage discharges). The survey on the health risks was carried out on 280 households and in 10 hospitals. The data obtained were analyzed using SAS software (2006). The physico-chemical results show that the waters sampled from wells were characterized by an acidic pH with average values varying between 4.42 and 6.3; high mineralization with an electrical conductivity that ranges between 212.13 and 400.06 µS/cm, high oxygenation (6.14 to 15.24 mg / l for COD, 4.67 and 7 mg / l for BOD5, 0.19 - 0.44 mg / l for TKN, 2.33 and 6.10 µg/l for copper, 0.37 - 0.86 µg/l for nickel and 0.05 to 2.6 µg/l for lead). Comparatively to the standards stewarding the quality of drinking water in Benin, the current results indicate pollution of water by organic matter. It is clear from the statistical analysis that pollution is favored by the influence of garbage discharges on these waters. The epidemiology survey showed that household's inhabitants located next to the dumpsite are most affected by the waste-related diseases, the most frequent were: malaria, lung affections, headache and gastroenteritis. Therefore, the problem of uncontrolled garbage discharges in the districts of Abomey and Godomey is an obvious emergency and requires efficient corrective measures.

Keywords: uncontrolled waste discharge, leach ate, impact, pollution, groundwater.

Résumé

Les décharges in contrôlées prolife rent les quartiers de ville et villages des arrondissements d'Abomey-Calavi et de Godomey. Les eaux usées qui y sont déversées et celles des pluies lessi vent ces décharges et produisent du lixiviat qui s'infiltre dans le sol et contamine les eaux souterraines. Pour évaluer le niveau de pollution de ces eaux par les décharges dans ces arrondissements, des analyses physico-chimiques ont été réalisées sur 21 échantillons d'eau prélevée dans les puits situés à proximité des décharges et dans une zone témoin situé environ à 7 km de ces décharges. L'étude sur les risques sanitaires à été réalisée auprès de 280 ménages et dans 10 centres de santé. Les données obtenues ont été analysées à l'aide du logiciel SAS (2006). Les résultats d'analyse ont montré que les eaux des puits prélevés ont un pH acide avec des valeur moyennes qui varient entre 4,42 et 6,3 ; une minéralisation élevée avec une conductivité électrique qui oscille entre 212,13 et 400,06 µS/cm, une forte oxygénation (valeurs moyennes variant entre 7,87 et 11,87mg/l), un faible tax de matières organiques et des métaux (teneurs moyennes comprises entre 6,14 et 15,24mg/l pour la DCO, 4,67 et 7mg/l pour la DBO5, 0,19 et 0,44mg/l pour l'NTK, 2,33 et 6,10µg/l pour le cuivre, 0,37 et 0,86µg/l pour le nickel puis 0,05 et 2,6µg/l pour le Plomb). Ces teneurs comparées à celles de la norme fix ant la qualité de l'eau potable au Bénin révèle la pollution des eaux par la matière organique. Il ressort de l'analyse statistique que cette pollution est favorisée par l'influence des décharges sur ces eaux. Aussi l'enquête épidémiologie a montré que les ménages habitants les voisinages des décharges sont les plus touchés par les maladies liées aux déchets dont les plus fréquentes étaient : le paludisme simple et grave, les affections respiratoires, la céphalée, les gastro-entérites. Alors le problème des décharges in contrôlées dans les arrondissements d'étude est d'une urgence évidente et nécessite que des actions promptes soient engagées.

Mots clés : Décharge in contrôlée, lixiviat, pollution, eau souterraine.

Introduction

Over the last three decades there has been increasing global concern over the public health impacts attributed to environmental pollution, in particular, the global burden of disease. The World Health Organization estimates that a quarter of the diseases occur due to prolonged exposure to environmental pollution. Most of these environment-related diseases are however not easily detected and may be acquired during childhood and manifested later in adulthood. Improper management of solid waste is one of the main causes of environmental pollution and degradation in many cities, especially in developing countries. Many of these cities lack solid waste regulations and proper disposal facilities, including for harmful waste. Such waste may be infectious, toxic or radioactive. Municipal waste dumping sites are designated places set aside for waste disposal. Depending on a city's level of waste management, such waste may be dumped in an uncontrolled manner, segregated for recycling purposes, or simply burnt. Poor waste management poses a great challenge to the well-being of city residents, particularly those living adjacent the dumpsites due to the potential of the waste to pollute water, food sources, land, air and vegetation. The poor disposal and handling of waste thus leads to environmental degradation, destruction of the ecosystem and poses great risks to public health.

In the districts of Abomey-Calavi and Godomey in Benin, household dumps abound of towns and villages. Since 2005, they are concentrated in the lowlands, old quarries and sand along the water. Therefore aesthetic pollution, air and water bodies are well known. One related to groundwater is not well known by the people because not visual or olfactory. This water pollution occurs through water infiltration into the soil. The sites of uncontrolled landfills that

have not been subject to any prior impact study, leachate essentially of dissolved organic matter and mineral compounds seep into the soil and contaminate them (Waste sum, 2010 and Daouda, 2012). The soil is the intersection point of several domains (the biosphere, atmosphere, and hydrosphere), contamination affects other components of the environment such as flora and groundwater (Piedrafita et al., 2007). Therefore, groundwater located next to the dumpsite may be subject of biological and chemical contamination. In the districts of Abomey-Calavi and Godomey in Benin, these waters are the main sources or drinkable water for the population. Consumption of such water can be the source of spread of various diseases (Salmonellosis, diarrhea and gastroenteritis). The current study aimed to highlight the influence of uncontrolled waste sites on the physico-chemical quality of groundwater and the health resident households in the districts of Abomey-Calavi and Godomey.

Study area

The study on the effect of landfill of untreated and uncontrolled waste discharges on water quality and human heath was carried out in the districts of Abomey-Calavi and Godomey in Bénin. The districts of Godomey and Abomey are located in the southern part of the municipality of Abomey-Calavi (Figure 1). They are the most densely populated district with the greatest population found in Godomey.

Materials and methods

Sampling of water from wells and physico-chemical analysis

Wells were selected near six disposal sites and in a control area characterized by the absence of waste discharge. The study involved 21 wells with 3 per each landfill site and by control area.

The various physico-chemical quality parameters of water taken at selected wells (pH, conductivity, dissolved oxygen, Total Kjeldahl Nitrogen (NTK) content, COD, BOD5, lead content, cadmium content, nickel content and copper content) are determined by standard methods. PH measurements were carried out by potentiometric method using a pH-meter and those of conductivity with a conductivity-meter pH/EC/TDS Family waterproof according to DIN EN 27888 (January 1994). The dissolved oxygen was determined by a standard electrochemical method (NF T 90-106) with an Oximeter Oxi 730 InoLab WTW (oxygen sensor). The total Kjeldahl Nitrogen was measured according to the standard DIN EN 25663 (January 1994), the COD according to AFNOR standard in force (NFT 90-101) by a volumetric method potassium dichromate titration with Mohr's salt and BOD5 by the man o metric method Oxi Top WTW without dilution. The protocol of the flame atomic absorption spectrometry was used for the assay of the water content in different metals.

Epidemiological survey

The epidemiological survey was carried out through two studies. The first targeted households located nearby landfill and those in the control area. It was performed using a survey forms with 40 household in each landfill site including 20 households located at 0 to 100m from the landfill sites and 20 others situated at 100 to 200m from the landfill sites. The same sizes were used in the control area. A total of 280 households were surveyed.

The second study on the epidemiological survey targeted the hospital. It took place in fourteen hospitals including 2 hospitals located in the in the vicinity of landfill sites and 2 in the control

area. It aims to strip the sick tracking records and assess the incidence of disease of the population from the study area.

Data processing and analysis of results

The collected data were analyzed with SAS 9.2 software. Means were calculated by *Proc means* procedure. The procedure *Proc GLM* was used for analysis of variance. The F test was used to evaluate the effect of region, of the depth, and the one of distance on the studied variables. The comparisons between means were made in pairs by the Student t test. The results were analyzed and compared to the drinking water quality standards used in Benin.

Results and discussion

Chemical parameters of leach ate and digests waste

The table 1 shows the physico-chemical parameters of leach ate and digests of extra fine of selected waste disposal sites. It appears that the leach ate and digests of extra fine landfill waste had a neutral pH. They have little oxygen, rich in minerals, organic matter, copper and lead and polluted by the oxidized organic matter (COD), lead and copper.

Influence of landfill sites on the physico-chemical quality of groundwater

Characteristics of the selected wells

All selected wells were of traditional types with rudimentary equipment. 81% were without protection while 19% were covered halfway with a slab, lids metal element or tree branches. The receptacles are generally abandoned or thrown on the ground, on the curb or on well cap. The distance between the wells and the landfill sites varies between 18 and 133 m for those located around the landfill sites and 6 and 7 km for those located in the control area.

Variation of Physico-chemical quality of wells water according to the depth

The table 2 shows the variation of physico-chemical quality parameters of well water according to the wells depth. The pH varied significantly ($p < 0.001$) according to the depth of well with the highest values recorded in well of small depth. COD was also significantly affected by the depth of the well ($p < 0.01$). This reflects a high concentration of organic matter in the water from shallow wells as deeper wells. For the other parameters, no difference was observed according to the depth. However, electrical conductivity, BOD5, nickel and lead contents tend to decrease with depth.

Effect of distance between the wells and the sites of landfill discharges on the physico-chemical quality of water

Table 3 shows the variation in the physico-chemical quality of the water according to the distance between the source of water and the sites of landfill discharges. All physico-chemical parameters studied except BOD5 did not change significantly ($p > 0.05$) with the distances between the source of water and the dumpsites. The average values of BOD5 indicate a low concentration of organic matter in water from wells which were very distant from landfill sites. However it should be noted that the average values of the other parameters vary according to the distance except lead content which was only recorded in the waters sampled from the wells situated near to landfills (between 20 and 37 m).

Impact of the zone on the physicochemical quality of well water

The variation of the physico-chemical properties of well water according to the area of sampling is given in Table 4. From this table, it can be observed that except pH and dissolved oxygen values, the other parameters studied did not differ ($p > 0.05$) according to the zone. However it should be noted that except lead content found only in water from wells located near to the landfills in the district of Godomey, the average values of the other parameters tend to be lower in well water in the control area than those located around the landfill sites.

Furthermore, the different values of physico-chemical parameters evaluated herein are below the standard except the pH and COD of well water sampled near to the landfill sites which exceeded the average values recommended by the standard.

Epidemiological study

Disease prevalence reported by households

The results of survey done with households who live near to the waste discharges on their health during the last six months prior to the survey are shown in Table 5. It comes out from this table that the diseases related to the presence of waste were predominant (91.33%) in the study areas. They were very common in households who live near to the landfill sites and dominant among households situated in the range from 0 to 100 meters from the landfill sites.

Monthly prevalence of diseases in the study areas

Figure 2 shows the monthly change in waste-related diseases during the last six months prior to the survey (February to July 2013). The results of the health survey carried out in the hospital confirmed the reports of the surveyed households. Diseases related to wastes were more frequent in households located next to the dumpsites and during the months of February, May, June and July.

Discussion

Characteristics of the selected wells

The wells sampled in the current study are mainly of traditional types and not protected. These results are similar to those of Degbey (2008). These authors reported that the wells of households in the commune of Abomey-Calavi are traditional, made by local diggers with rudimentary equipment, with small diameter, less deep (1-15 m) and have rudimentary protection systems such as the lip, the cover and the anti-quagmire slab.

Influence of the waste landfill on physico-chemical quality of groundwater

From the results of physico-chemical analysis, the average values measured show that the pH of the sampled water was acidic and varies significantly according to the location of the well site (Abomey-Calavi *vs* Godomey). The water samples collected from wells situated around landfill sites in the district of Abomey and in the control area of this district were more acidic than those from wells situated near to the landfill sites in the district of Godomey. This acidity of waters may be related to the nature of the soil traversed. But the strong acidity of the water found in wells situated around the landfill sites in the district of Abomey-Calavi in comparison to the wells in the control area can only be related to the organic matter and the release CO2 mainly

from landfill sites. These observations are consistent with those of Mehdi et al. (2007). These authors also found that water from wells that are close to the landfill of the city of Tiaret (Algeria) was more acidic. They justified this by the influence of the release of CO2 discharge on groundwater. According Tapsoba (1995), Matini et al. (2009) and Ahoussi et al. (2010), the acidity of waters in the tropics can mainly due to the decomposition of plant organic matter, with the production of CO2 in the soil.

The dissolved oxygen was also affected by the location of the well sites. The wells in the control area are less oxygenated. These wells are very deep and poor in organic matter, the origin of the sub-oxygenation of water from these wells would be tied to exchange air-water and light penetration (IBGE, 2005 and Belghiti, 2013). This situation can promote the development of pathogenic genes.

For the electrical conductivity, waters sampled from wells located near to the landfill sites tend to be more mineralized (322.1 and 370.2 mg /L) than those sampled from wells located in the control area (212.3 m/L) (Table 16 and Figure 32a). These values are higher than those found by Khattaabi (2001) in water from wells located close to a household garbage dump in France (32-245 S/cm) and less than those of the wells found near the landfill in Oujdad in Morocco (970-31660 microseconds/cm). The high mineralization in water of wells situated nearby landfill sites can only be due to the infiltration of leachate generated by highly charged mineral dumps. Rassam et al. (2012), Chofqi et al. (2004) and Djorfil et al. (2010) reported similar findings. They noticed that the water of wells located near the landfill sites have a higher salinity than those from distant wells.

Influence of waste sites on the organic parameters of groundwater

As conductivity, mean levels of COD (11.66 and 13.66 mg / L), BOD5 (5.89 and 7 mg / L) and NTK (0.47 and 0.43 mg / L) of water from wells located around the waste sites appear to be higher than those of the wells of the control area (DCO = 6.17 mg/L BOD5 = 4.67 mg/L and NTK = 0.19 mg/L). This reflects a greater load of organic matter in water wells situated near to the landfill sites. The levels of these parameters in the collected well waters indicate pollution in organic matter.

The average concentrations of these parameters are very low compared to those obtained by Mehdi et al. (2007) (COD ranging between 32 and 82 mg/L; BOD5 between 20 and 40 mg/L). However, these authors had reported the same conclusion. They also found that water from wells located near to landfills are richer in organic matter than more distant wells. Chofqi et al. (2004) also made the same findings. They had explained this situation by the decomposition of putrescible wastes which percolate through leach ate to reach the groundwater.

Influence of the waste sites on toxicological parameters of groundwater

The average concentrations of heavy metals obtained herein in well water are very weak. However, the highest content in Nickel, Copper, lead and Cadmium (oscillating respectively between 0.05 and 0.086 mg/L, 2.48 and 3.14 mg/L; 0 and 2.6 mg/L) are found in wells located next to dumpsites while the lowest values were recorded from the control area. These low observed values confirm several reports which showed that nickel is typically found in groundwater in low concentrations or absent (Boucheseiche *et al.*, 2002 ; Santé-Canada, 1994). Keilah et al. (2007) have obtained in water sampled from wells near to waste discharge in the village Hêvié in the town of Abomey-Calavi lead content ranging between 0.5 and 2 mg/l. In

Morocco, Rassam et al. (2012) found in groundwater located next to the dumpsites of the city of Al-Hoceima, the following concentrations: nickel content ranging between 0.14 and 0.16 mg/l, copper content ranging from 0.01 and 0.034 mg/l). Mehdi, et al. (2007) found in well water sampled next to the dumpsite of the town of Tiaret (Algeria) some nickel concentrations ranging from 0.56 to 0.88 mg/l. In groundwater located next to the dumpsites of the city of Oujda (Morocco), the cadmium and nickel levels were very low (0.003 to 0.1 mg/L for cadmium and from 0.05 to 0.11mg/L for nickel). Copper and lead were absent (Kharmouz, 2013). The very low levels of metals in water sampled from wells in this study can be explained by the retention of metals in soils related to their purifying power. As for the highest concentrations of physic-chemical parameters in water from wells located next to the dumpsites recorded, they can be justified by the infiltration of landfill leach ate into the ground.

The values recorded herein are below the standard limits recommended for the quality of drinkable water in Benin. According to Jourdan et al. (2005), metals whose contents do not exceed the standard limits can be a health hazard. Indeed, bioaccumulation of these elements can become toxic, so the consumption of water from sampled wells can be considered as a risk for its consumer health.

Health profile of households located next to the dumpsites

The diseases were more frequent at the households located between 0 and 100 m from landfills but less important in households located between 100 and 200m from landfills and in the control area. This is evidence of a cause-effect relationship between diseases and landfill sites. This finding is similar to the results obtained by Kientga (2008). He also showed a trend of dependency diseases compared to the distance of waste deposits. Chofqi et al. (2004) also noted that the population located next to the dumpsites of the city of El Jadida in Morocco is affected in its active portion by allergic diseases (lung, skin, eye and conjunctivitis ...). They mentioned that children and babies are the most vulnerable to these affections. The sources associated with these diseases are especially poisoning through inhalation, ingestion and skin absorbtion. According to, the dumpsite exposes the residents around it to unacceptable levels of environmental pollutants with adverse health impacts. A high number of children and adolescents living around the dumping site had illnesses related to the respiratory, gastrointestinal and dermatological systems such as upper respiratory tract infections, chronic bronchitis, asthma, fungal infections, allergic and unspecified dermatitis/pruritis – inflammation and itchiness of the skin.

Conclusion

Overall, it comes out from this study that well water showed high mineralization, high oxygen, low organic matter content and a very low concentration in metals. The physic-chemical parameters of sampled water evaluated herein depend on the distance between waste landfill sites and the source of water, the depth of the wells and the region. In terms of the pollution of water, only water wells located next to the dumpsite showed pollution by oxidizable organic matter (COD). At the same time, an epidemiological evaluation of the population (children, adolescents and adults) living and schooling near the dumpsite indicates a high incidence of diseases that are associated with high exposure levels to these pollutants. Once deposited, the metals are not degraded and persist in the environment for many years poisoning humans through inhalation, ingestion and skin absorption. Acute exposure leads to nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis. The households located next to the

dumpsite are the most affected by these diseases. The most important of all known diseases were malaria, lung infections, gastroenteritis and headache. It is then necessary to enhance the management of household waste and dumpsites in order to improve environment and human health.

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Table 1: Physico-chemical parameters of leach ate and digests of extra fine elements of dumpsites

Variables		District of Abomey-Calavi		District of Godomey		Norme	ANOVA
	Parameters	Mean	SE	Mean	SE		
Leachates	pH	6.87	0.05	7.1	0.19	**5.5-8.5**	NS
	Cond (µS/cm)	815.33	135	595	110	**2100**	NS
	OD (mg/l)	2.2	0.81	2.37	1.07	**> 5**	NS
	DCO (mg/l)	291.2	66.1	425	144	**125**	NS
	DBO5 (mg/l)	26.66	5.36	19.66	3.21	**30**	NS
	DBO/DCO	-	-	-	-	**-**	-
	DBO5/DCO	-	-	-		**-**	
	NTK (mg/l)	2.99	0.57	2.52	0.74	**30**	NS
	DBO5/NTK	-	-	-	-		-
Digests (Mineral deposits)	Ni (mg/l)	2.06	0.11	1.38	441	**1**	NS
	Cd (mg/l)	nd	nd	nd	nd	-	-
	Cu (mg/l)	10.03	1.82	4.21	0.33	**1**	*
	Pb (mg/l)	520	516	4.42	2.29	**0.1**	NS

Table 2: Influence of the depth of the wells on the physico-chemical quality of the water

Variables	Depth : 1-7 m		Depth : 12-14m		Depth : 21-25m		ANOVA
	Mean	SE	Mean	SE	Mean	SE	
pH	6,01	0,25	4,42	0,21	5,90	0,15	***
Cond (µs/cm)	379,2	43,50	280,20	64,00	212,30	63,10	NS
OD (mg/l)	9,29	0,66	11,85	0,45	7,87	0,39	NS
DCO (mg/l)	14,87	3,44	7,63	0,84	6,17	0,58	**
DBO5 (mg/l)	6,75	0,39	5,83	0,79	4,67	0,88	NS
NTK (mg/l)	0,44	0,24	0,47	0,47	0,19	0,19	NS
Ni (µg/l)	0,76	0,50	0,52	0,46	0,37	0,32	NS
Cu (µg/l)	5,73	2,55	1,4	0,733	2,43	2,43	NS
Pb (µg/l)	1,95	1,95	nd	nd	nd	nd	NS

OD = Dissolved Oxygen; Cond = Conductivity; SE = Santard Error; NS = Not significant; ***: P<0.001; **: P<0.01.

Table 3: Variation of the physico-chemical quality of the water according to the distance well-dumpsites

Variables	Distances well-dumpsite (m)								ANOVA
	20-37		39-65		86-133		6000-7000		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	

pH	5.25	0.36	6.03	0.34	5.07	0.85	5.9	0.15	NS
Cond (µs/cm)	317.1	46.9	403.3	71.6	319	108	212.3	63.1	NS
OD (mg/l)	10.91	0.31	8.63	1.41	10.87	0.71	7.87	0.93	NS
DCO (mg/l)	12.55	2.85	15.29	5.92	6.49	1.02	6.17	0.58	NS
DBO5 (mg/l)	6.67	0.41	07	0.45	4.67	1.45	4.67	0.88	*
NTK (mg/l)	0.47	0.33	0.28	0.28	0.74	0.75	0.19	0.19	NS
Ni (µg/l)	0.47	0.33	1.1	0.99	0.47	0.33	0.37	0.032	NS
Cu (µg/l)	2.33	0.73	9.37	0.47	00	00	2.43	2.43	NS
Pb (µg/l)	2,6	2,6	nd	nd	nd	nd	nd	nd	NS

OD = Dissolved Oxygen; Cond = Conductivity; SE = Santard Error; NS = Not significant; ***: P<0.001; **: P<0.01.

Table 4: Effect of the zone on the physicochemical quality of well waters

Variables		Control Zone		Abomey-Calavi		Godomey		
	Norms (mg/l)	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	ANOVA
pH	**6,5-8,5**	5.9	0.15	4.75	0.36	6.21	0.12	**
Cond (µs/cm)	**400**	212.3	63.1	322.1	52.8	370.2	52.7	NS
OD (mg/l)	**>5**	7.867	0.393	11.367	0.408	8.922	0.841	*
DCO (mg/l)	**<10**	6.173	0.575	11.66	3.02	13.25	3.96	NS
DBO5(mg/l)	**<5**	4.667	0.882	5.889	0.611	7	0.373	NS
NTK (µg/l)	**1**	0.187	0.187	0.467	0.33	0.436	0.292	NS
Nickel (µg/l)	**0,02**	0.037	0.032	0.05	0.033	0.086	0.066	NS
Cu (µg/l)	**2**	2.43	2.43	2.48	0.75	6.10	3.44	NS
Pb (µg/l)	**0,05**	00	00	00	00	2.6	2.6	NS
Cd (µg/l)	**-**	nd	nd	nd	nd	nd	nd	-

OD = Dissolved Oxygen; Cond = Conductivity; SE = Santard Error; NS = Not significant; ***: P<0.001; **: P<0.01.

Table 5: Health effects from exposure to uncontrolled household wastes

	Sites de décharges			
Variables	**0 – 100 m**	**100 – 200 m**	**Control zone**	**Total**

	Affections	N	%	N	%	N	%	N	%
Diseases caused by dumpsites	Diarrhea	38	19.59	7	5.88	0	0.00	45	13.01
	Typhoid Fever	9	4.64	2	1.68	1	3.03	12	3.47
	Lung Diseases	58	29.90	16	13.45	5	15.15	79	22.83
	Headaches	2	1.03	0	0.00	0	0.00	2	0.58
	Stomach Pain	1	0.52	5	4.20	0	0.00	6	1.73
	Sore Eyes	11	5.67	2	1.68	0	0.00	13	3.76
	Malaria	75	38.66	60	50.42	24	72.73	159	45.95
	Total	**194**	**100.00**	**92**	**77.31**	**30**	**90.91**	**316**	**91.33**

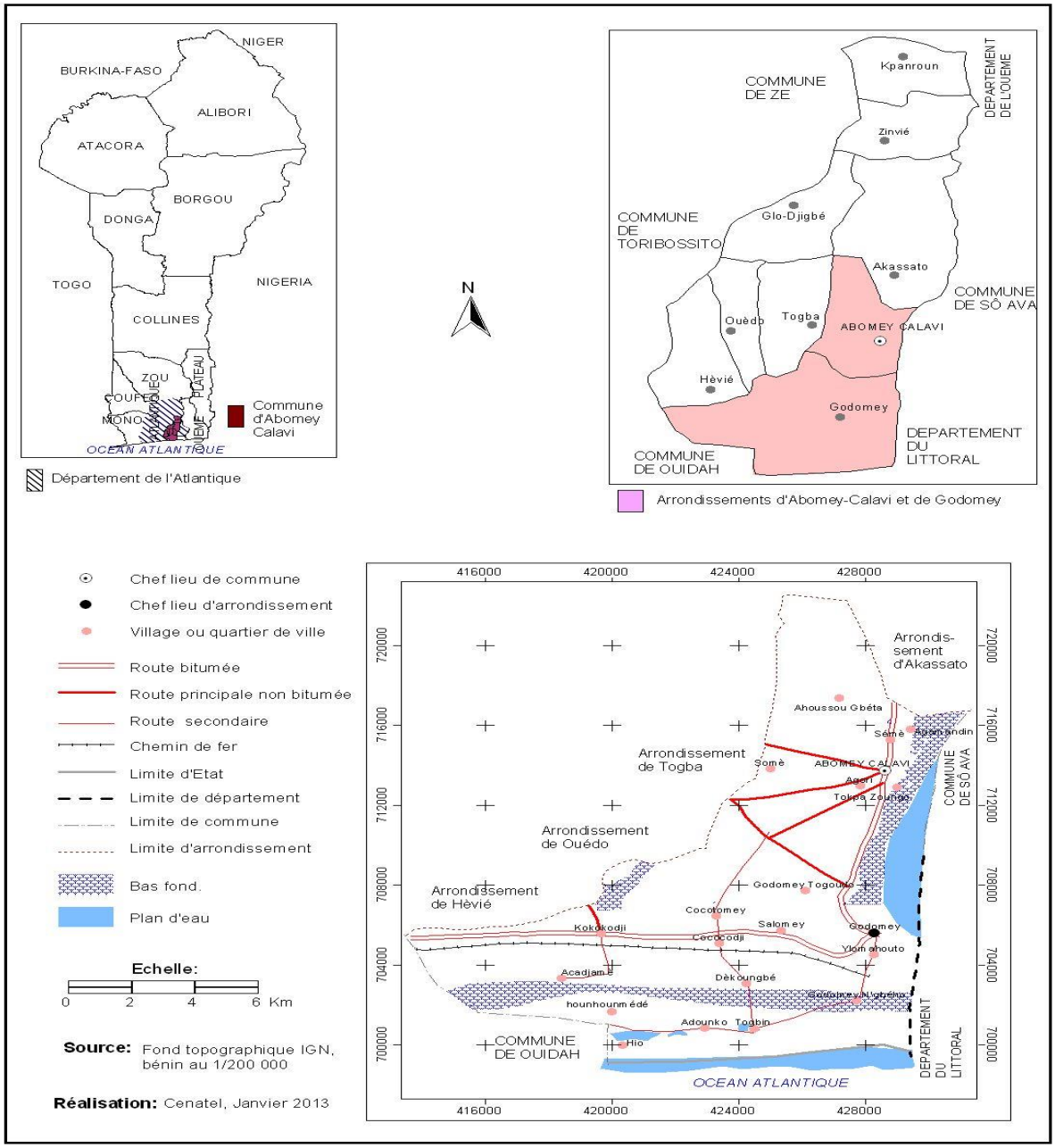

Figure 1: Study area

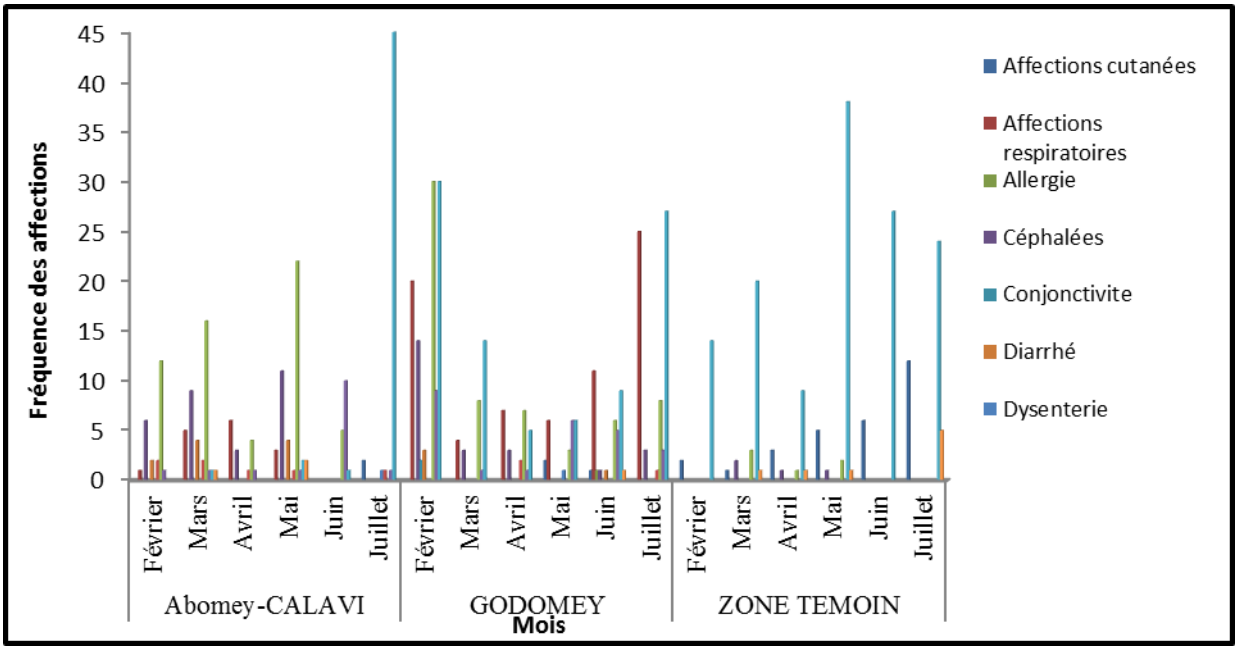

Figure 2: Monthly frequency of waste-related diseases reported by hospital