Pollution Loading to the Caribbean Sea from rivers in the capital city of The Dominican Republic

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The Caribbean Sea is facing an environmental problem caused by the pollution discharged by rivers flowing through Santo Domingo, Dominican Republic. The objective of this study is to survey the present condition of the pollution of rivers Haina, Ozama and Isabela to be able to understand the changes in the watershed and their causes. Results show that the water in HN River has a high salinity level from the mouth until about 5 km upstream. Salinity of OZ-IS River decreases significantly 2 km upstream from the mouth, after the floating bridge. Cross correlation of water quality parameters in HN and OZ-IS River was found. In OZ-IS River there was no correlation between Chl-a and DO, and SS and turbidity while there was correlation between Chl-a and turbidity. The concentration of SS in OZ-IS River is 5 or more times higher in the mouth compared with that in the upstream. River water around populated areas have a very high value for Chl-a showing characteristics of eutrophic water bodies.

Key Words : *Caribbean Sea ,river pollution, Chlorophyll-a, eutrophic water body.*

1. INTRODUCTION

Santo Domingo Metropolitan Area, the capital of the Dominican Republic faces the Caribbean Sea, which is known as one of the world's leading tourist destinations. The main infrastructures and economic activities are located in the margins and in the coastal zone. They include trade, manufacturing industries, port activities and agro-industries. Industrial and domestic wastes are discharged directly, virtually untreated, into the rivers and therefore into the coastal waters. Here, they are exposed to marine currents and are quickly redistributed along the coast, with a growing deterioration of coastal areas and the loss of their natural landscape (Villasol et. al, 1998). Especially, the coastal area is facing an environmental problem caused by the pollution discharged by rivers flowing through the Caribbean Sea. However, as this occurs in open sea, it is difficult to notice the problem ant there is little concern about the monitoring of the water quality of the rivers.

Around Santo Domingo Metropolitan Area there are three main rivers, Ozama, Isabela and Haina. Ozama and Haina rivers discharge their flows to the Caribbean Sea, while Isabela River discharge its flow to Ozama River at around 10 km from its mouth.

Studies regarding the water quality of rivers such as Ozama, Isabela and Haina located around Santo Domingo are very few although the former research by Soldner et al. (2004), Sherman et al. (2003), and Brandimarte et al. (2009) are enumerated as researches on the river basin in the

Dominican Republic.

Therefore, the objective of this study is to survey the present condition of the pollution of rivers Haina, Ozama and Isabela that discharge their flow into the Caribbean Sea, so as to understand the changes in the watershed and their causes.

2. METHODS

(1) Study site

In this study sampling was performed in the sailable part of Haina River (HN); Ozama River and Isabela River some few kilometers upstream their junction and from their junction to the river mouth, we refer in this study as OZ-IS River.

Santo Domingo littoral zone, located at the south of the Dominican Republic, is an open coastal zone, delimited by OZ-IS River in the east and the HN River in the west. The basic information about Ozama, Isabela and Haina rivers is shown in Table 1.

Table 1 Overview of Ozama, Isabela and Haina rivers (De La Fuente, 1976)

River name	Length (km)	Watershed (m^2)	Slope (%)
Haina	86	621	0.23
Ozama	148	2706	0.28
Isabela	59	376	1.12

(2) Field Survey

The location of the research area, HN and OZ-IS rivers, sampling points and some photographs related to pollution sources of the rivers are shown in Fig.1. The field survey was performed on January 29th and March 9th, 2011 in HN River; in January 30th and March 10th, 2011 in OZ-IS River using a small vessel. The main parameters of water quality measured were pH, dissolved oxygen (DO), water temperature, salinity, chlorophyll-a (Chl-a), suspended solids (SS) and turbidity among others. All these parameters with exception of SS were measured directly by a portable water quality meter (TOA-DKK WQC-24-1-3). Suspended solids were quantified at the laboratory from the filter paper weight difference before and after filtration.

Moreover, the Chl-a data measured with the water quality sensor ($Chl\text{-}a_{sensor}$) was compared with the Chl-a measured by standard method (APHA, AWWA, WEF, 1998) in the laboratory. The following conversion equation was obtained.

$$Chl\text{-}a_{Extr} = 2.25 Chl\text{-}a_{sensor} + 1.86 \quad (n=5, r=0.93) \qquad (1)$$

Total nitrogen (T-N) and total phosphorous (T-P) were analyzed at the laboratory using Hach reagents and spectrophotometer.

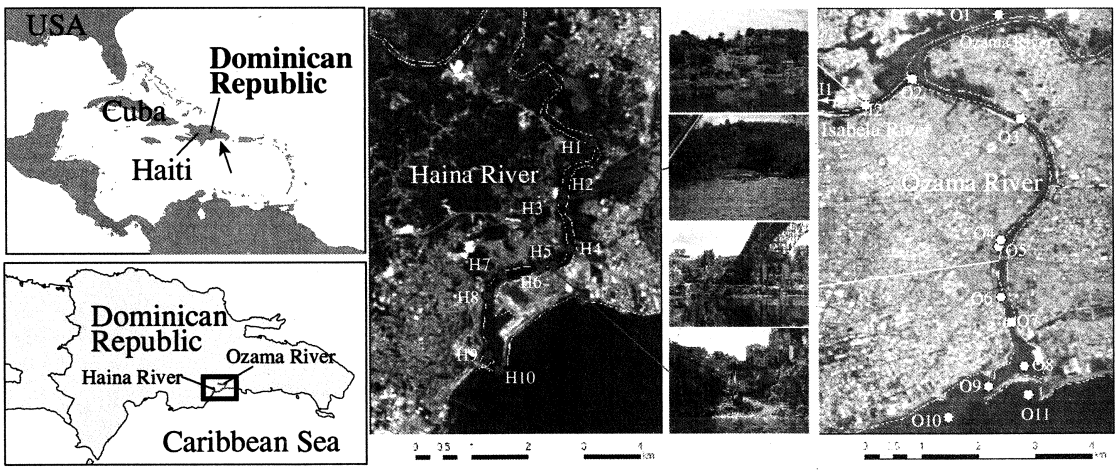


Fig.1 Study area (Dominican Republic)

3. RESULTS AND DISCUSSION

(1) Overview of water quality

The overview of the surface water quality measured is shown in Table 2. Among these, the minimum value of surface DO in OZ-IS River was 0.3mg/l. The standard for anoxic water mass at the bottom layer of the coast in Japan is about 3 mg/l or less, thus the minimum measured value for DO is very low. Moreover, the maximum value of Chl-a known as one of the pollution index was 170 – 220 μg/l in both rivers. This concentration range is very high because the standard concentration range for Chl-a is 25 – 75 μg/l, and 75 μg/l or more

respectively in Japanese eutrophic and hypertrophic lakes respectively.

Table 3 shows T-N and T-P data from samples taken in March. In Japan a lake is considered in eutrophic state when T-N and T-P values are over 1 mg/l and 0.1 mg/l respectively. From data in table 3 it is possible to notice that the rivers are in highly eutrophic state, confirming the previous statement.

Table 2 Overview of surface water quality parameters

(a) 29-30 Jan., 2011

	HN River		OZ-IS River	
Parameters	Min.	Max	Min.	Max
Depth(m)	1.2	10.0	3.6	14.0
pH	8.0	8.6	7.5	7.9
DO(mg/l)	5.8	12.1	0.3	9.3
Temp. (°C)	27.9	30.5	25.5	27.3
Salinity	21.5	29.2	0.7	21.0
Chl-a(μg/l)	94.1	220.9	1.9	81.5
SS(mg/l)	27.2	71.8	5.7	238.9
Turb. (NTU)	3.0	14.5	1.7	28.0

(b) 9-10 Mar., 2011

	HN River		OZ-IS River	
Parameters	Min.	Max	Min.	Max
Depth(m)	3.0	9.3	3.1	9.5
pH	7.8	8.1	7.4	8.5
DO(mg/l)	7.6	16.9	2.1	10.7
Temp.(°C)	26.7	28.5	26.5	27.9
Salinity	14.8	28.5	0.7	32.1
Chl-a(μg/l)	0.0	56.8	0.0	169.9
SS(mg/l)	30.5	61.2	7.1	138.5
Turb. (NTU)	2.1	9.1	0.0	26.8

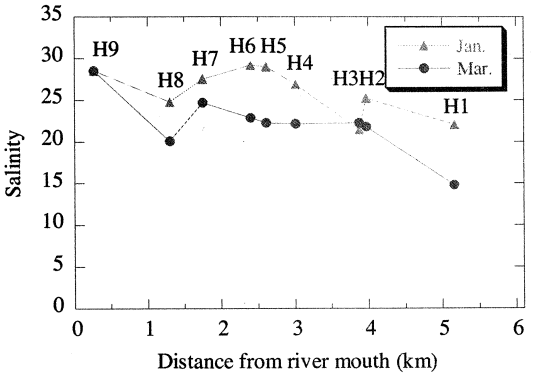
Table 3 T-N and T-P in 9-10 Mar., 2011

Rivers	T-P(mg/l) Min-Max	T-N(mg/l) Min-Max
Haina	0.15-1.41	0-6
Ozama-Isabela	0.70-16.3	0-8

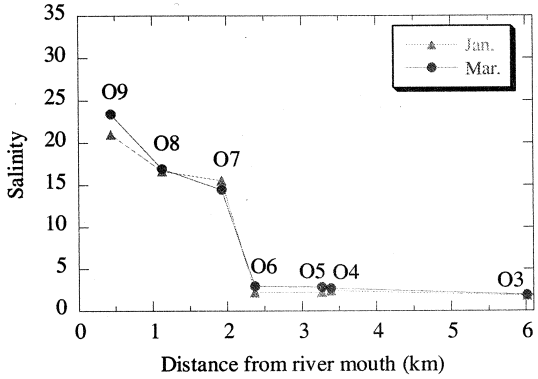
(2) Salinity distribution

The horizontal distribution of the surface salinity in both rivers is shown in Fig.2. High salinity (20-30) is observed in HN River until about 5-km upstream. In OZ-IS River there is a remarkable difference at about 2-km upstream from the river mouth (between O7 and O6). This is may be due to the existence of a floating bridge (FB) between these points (Fig. 3), the structure of the bridge may be inhibiting the exchange of sea water.

Figure 4 shows the horizontal distribution of salinity, SS and Chl-a in OZ-IS River. It is also possible to notice that at about 2-km upstream there is a sudden increase of Chl-a and a decrease of SS. This may be an effect of the FB or location of the discharge pipes of the sewage system. Neither of these could be confirmed yet.



(a)Haina River



(b)Ozama River

Fig.2 Horizontal distribution of salinity in HN and OZ-IS rivers

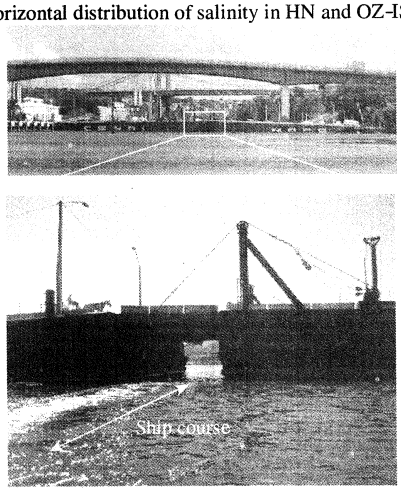


Fig.3 Photos of floating bridge near OZ-IS River point O7.

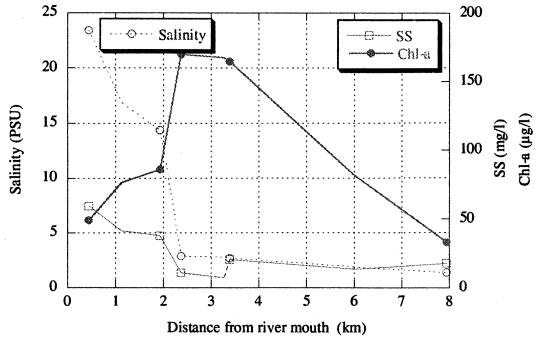


Fig.4 Horizontal distribution of salinity, SS, and Chl-a in OZ-IS River, Mar. 2011

(3) Relationship between Chl-a and other parameters

Cross correlation of Chl-a and other water quality parameters which serve as contamination index are shown in Fig.5. Among these, significant correlation between Chl-a and DO was not observed in HN River. Positive correlation between Chl-a and salinity in OZ-IS River was observed from the river mouth up to 2-km upstream. Negative correlation between Chl-a and salinity in OZ-IS River was found 2-km upstream onwards.

Since Chl-a and SS did not correlate, the basic component of SS may not be of phytoplankton origin. Moreover, since there was no correlation between turbidity and SS, the composition of turbid materials are different. The composition may change significantly all over the basin, and a detailed analysis of the SS composition should be performed.

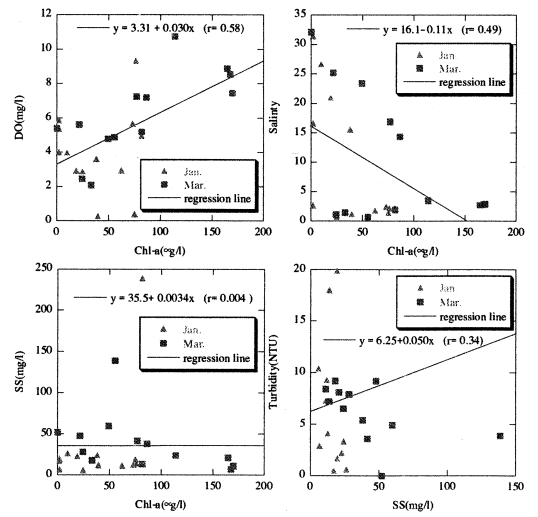


Fig.5 Cross correlation of water quality parameters in OZ-IS River, Jan.30 and Mar.10, 2011

(4) Characteristics of SS and Chl-a distributions

The horizontal distributions of SS and Chl-a in OZ-IS River are shown in Fig.6. As it is possible to see, surface SS concentration is 5 or more times higher in the river mouth than in the upstream. Concentration of Chl-a higher than 160 μg/l can be observed near the populated areas (O4, O5, O6). The concentration of Chl-a in OZ-IS River near populated areas exceeds the maximum value of eutrophic water bodies in more than 2 times.

The horizontal distributions of SS and Chl-a in HN River are shown in Fig.7. As it is possible to see, surface SS concentration is high in the river mouth and in locations near populated areas. With the difference of the river mouth, concentration of Chl-a is also high near the populated areas. This river also has Chl-a values corresponding to an eutrophic body of water, even though values are much lower than in OZ-IS River.

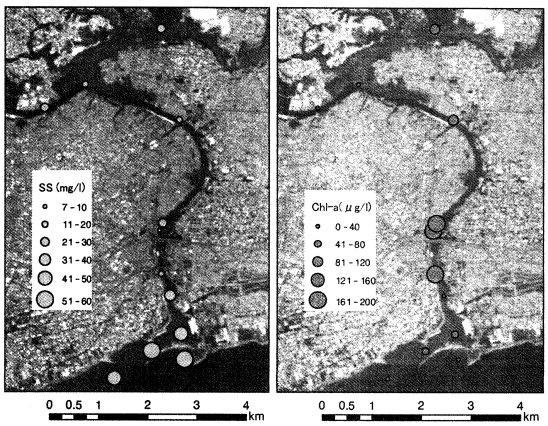


Fig.6 Horizontal distributions of SS and Chl-a in OZ-IS River, Mar. 10 , 2011

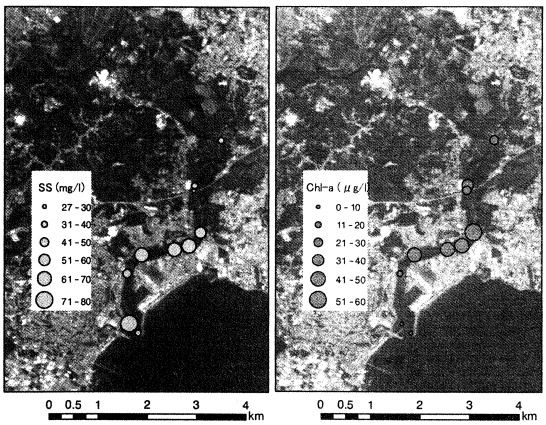


Fig.7 Horizontal distributions of SS and Chl-a in HN River, Mar. 10 , 2011

4. CONCLUSIONS

The main conclusions obtained are as follows:

- The water in HN River has a high salinity level from the mouth until about 5 km upstream. Salinity of OZ-IS River decreases significantly 2 km upstream from the mouth, after the floating bridge.
- The cross correlation of water quality parameters in HN and OZ-IS River was found. In OZ-IS River there was no correlation between Chl-a and DO, and SS and turbidity while there was correlation between Chl-a and turbidity.
- The concentration of SS in OZ-IS River is 5 or more times higher in the mouth compared with that in the upstream.
- River water around populated areas show very high values for Chl-a.

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