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HUMAN SYSTEMS

MONITORING ENVIRONMENTAL INDICATORS ON ISABELA ISLAND TO PREVENT AND REDUCE POLLUTION

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The **Galapagos National Park Directorate** has its headquarters in Puerto Ayora, Santa Cruz Island, Galapagos and is the Ecuadorian governmental institution responsible for the administration and management of the protected areas of Galapagos.

The **Governing Council of Galapagos** has its headquarters in Puerto Baquerizo Moreno, San Cristóbal Island, and is the Ecuadorian governmental institution responsible for planning and the administration of the province.

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Monitoring environmental indicators on Isabela Island to prevent and reduce pollution

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Introduction

Despite the progress in the conservation of the protected areas of Galapagos, little has been done to determine the status of the environmental quality in human-inhabited areas. Although the urban and rural areas of the Archipelago represent only 3% of the total area, they constitute one of the main sources of environmental pollution. In its recent Management Plan, the Galapagos National Park Directorate (GNPD) recognizes the Archipelago as a socioecosystem where there are permanent interactions between the inhabited areas and protected marine and terrestrial natural areas, and therefore a need for integrated management (DPNG, 2014). The GNPD is also responsible for developing the necessary mechanisms and strategies to achieve the highest standards of environmental quality, in coordination with municipal governments and Galapagos civil society.

Galapagos has lacked proper urban planning and technical capacity since the first human settlements. As a result, the resident population does not yet have basic services, such as potable water, storm drains and sewers, sewage treatment, and hazardous waste management. For example, hazardous waste is not managed as directed by the 142 Ministerial Agreement issued by the Ministry of the Environment (MAE, 2012). Also, studies of environmental contamination sites show evidence of negative impacts in protected areas as well as on human health.

A study in 2007 found that water sources in Santa Cruz and San Cristóbal are contaminated with fecal coliform (Cordova *et al.*, 2007a,b). Since that time no further studies or regular water quality monitoring has been conducted at source points. Water quality studies have also not been carried out at public recreation sites, and no information is available on soil contamination, even though pollution from fuel, oil, paint, solvents, and other substances used by mechanics and in boat maintenance workshops is obvious.

On Isabela one of the main problems is the lack of basic services for a growing resident and visitor population, which is also true for the other three cantons. According to the censuses of 2001 and 2010, the Isabela population grew by 39.3% in nine years, from 1619 inhabitants in 2001 to 2256 in 2010. This growth rate is higher than on Santa Cruz (35.1%) or San Cristóbal (32.7%) during the same period (INEC, 2001 & 2010). The number of tourists increased by 46.7% in the five years from 2003 to 2008 (GADMI, 2010).

Unplanned development can potentially contribute to a deterioration of water, soil, and air quality.

Water: The quality of the water resource is the most vital in terms of public health due to its scarcity and its direct use and consumption by the population. In 2009 it was estimated that approximately 70% of diseases in Puerto Villamil resulted from consumption or exposure to contaminated water (Walsh *et al.*, 2010).

Soil: Soil contamination issues are not perceived to be as urgent or in need of attention as water contamination, because the pollutants do not disperse as quickly in soil as they do in water. However, some highly mobile soil contaminants can reach the water table and contaminate water resources. This is particularly dangerous given that the local geology is characterized by a thin layer of soil and fragmented rock with high permeability.

Air: Air pollution in populated areas is a site-specific problem and depends solely on the location of the few potential sources of pollution (e.g., power plants). However, air pollution can become a public health problem when allowable limits are exceeded at these sites.

In view of the lack of available data, WWF and the Autonomous Decentralized Municipal Government of Isabela (GADMI – Spanish acronym) began a process to develop baseline information on current primary sources of contamination, generate indicators that will allow continued monitoring of pollution levels, and develop environmental management action plans to mitigate these sources of pollution.

Methods

The monitoring sites for examining water, soil, and air quality were defined according to the information provided by GADMI, as well as at potential contamination sites (Figures 1, 2 and 3).

Figure 1. Location of water quality monitoring sites in Puerto Villamil.

Water: To determine the quality of water piped for domestic use, the four water catchment sources were used: Chapin I, Chapin II, Manzanillo, and San Vicente. In some houses, tap water was also examined to identify possible in-transit contamination due to contact with wastewater from leaking pipes. To determine seawater quality at recreation sites, the following sites were selected: the Embarcadero (due to the presence and maintenance of boats) and Estero and Concha de Perla (both tourism sites). It was important to also determine the water quality in the crevice at the municipal workshops (Grieta de los Talleres) because this source provides water to 10 families in the Pedregal neighborhood. Wastewater was also monitored. Sampling was conducted five times over a four-month period, with a total of 240 individual samples collected. The following water quality parameters were analyzed in a certified laboratory: general parameters, heavy metals, hydrocarbons (PAH, TPH), anions, biological parameters (chemical oxygen demand – COD; biological oxygen demand - BOD), total coliforms, fecal coliforms, and chlorophyll a. Direct measurements were also made of: conductivity, dissolved oxygen, total dissolved solids (TDS), pH, redox, and temperature. The water sampling methodology was carried out according to the standards of the Ecuadorian Institute of Standardization (INEN – Spanish acronym)[1].

[1]PAH: petroleum aromatic hydrocarbons; TPH: total petroleum hydrocarbons; COD: chemical oxygen demand; BOD: biological oxygen demand; TDS: total dissolved solids; SOX: sulfur oxides; NOX: nitrogen oxides; MP: particulate matter; O3: ozone.

Soil: Soil monitoring was carried out at the following potential contamination sites: municipal workshops, Governing Council workshops, the gas station, the power plant, and the Embarcadero (for potential oil contamination). In addition, soil samples were collected from the four water catchment sources. Samples were also taken from the mud that accumulates at the sewage discharge site near the treatment plant. In total, two series of soil samples were collected over a period of four months. The samples were analyzed in a certified laboratory for the following: general parameters, heavy metals, and hydrocarbons (TPH).

Air: Air quality was monitored at five passive stations during a 30-day period: the power plant, the Embarcadero, municipal workshops, Governing Council workshops, and the municipal plaza. The towers of Chapin I and a weather station at the old police station were used as control sites. Air quality was determined by measuring the following: general parameters, SOx, NOx, PM, O3, and benzene.

Results of the analyses were compared with established national limits published in the Unified Text of Secondary Environmental Legislation of the Ministry of the Environment (TULSMA – Spanish acronym; MAE, 2003), which indicates the water quality parameters for: human consumption and household use, the preservation of the flora and fauna in marine waters and estuaries, and water discharge into the sea. This legislation also defines soil quality criteria for different uses and general regulations regarding the concentration of air pollutants. In the case of standards not included in TULSMA, parameters were compared with limits defined by INEN or with international standards, when national standards did not exist.

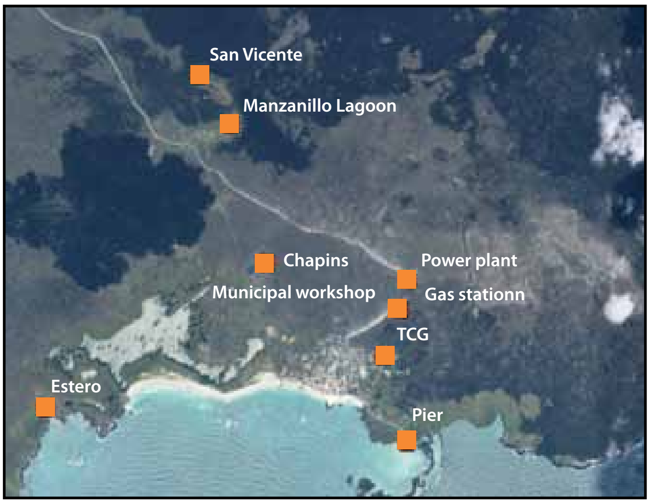


Figure 2. Location of soil quality monitoring sites in Puerto Villamil.

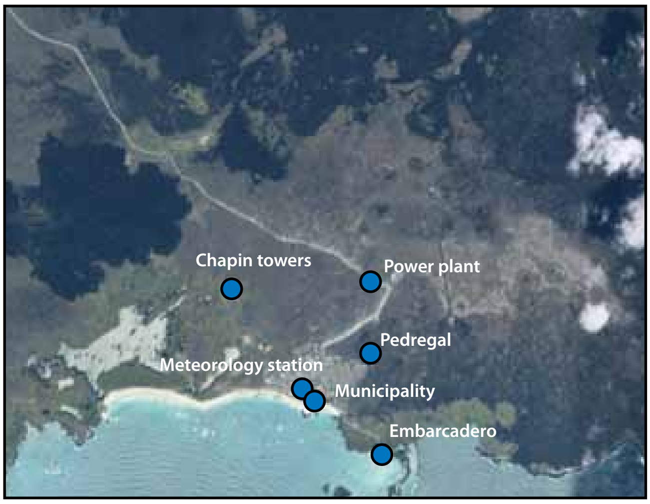


Figure 3. Location of air quality monitoring sites in Puerto Villamil.

Results and Discussion

Water quality

The results of the analysis of water sources varied significantly from site to site. Some samples showed extreme levels of certain contaminants (Table 1). This was expected because recharging the water sources is affected by the tides, and pollutants are diluted or concentrated according to water input (Table 1).

Certain findings require attention because of the deterioration of water quality and potential effects on health. Total dissolved solids exceeded the norm at all water sources in all surveys, due to the intrusion of seawater. The concentration of phosphate in all samples exceeded the limit set by INEN. High phosphate concentrations at water sources can result in a growth of algae that consume dissolved oxygen, which drastically lowers the water quality for human consumption and which can also cause kidney damage if the water is consumed in excess (Lenntech, 2013). Levels of manganese were also above the norm, which can change the taste of the water and stain kitchenware and clothing (OMS, 2006). Excess sodium alters the taste of the water (OMS, 2006). The most obvious contamination problems occurred in the water sources Chapin I and II, due to their proximity to the populated area and the improper design of the water catchment infrastructure.

The presence of fecal coliforms was detected on at least two occasions in Chapin I and II, with concentrations far above the norm (Table 2). The highest concentration of fecal coliform was in Chapin II with 90 MPN/100 mL, compared to INEN standards, which indicate a maximum limit of 1.1 MPN/100 mL. The analysis of the tap water of some houses in Puerto Villamil was characterized by high conductivity values and one of the samples showed the presence of fecal coliform, which can be produced by the contamination of piped water by wastewater due to sewage system problems on the island (Table 2).

Table 1. Analysis of water samples collected between May and July 2013 from domestic use sources indicate elevated levels in some parameters in comparison with the national norms established by TULSMA or in comparison with international standards in cases where no limits are defined by TULSMA.

Site	Chapín I	Chapín I	Chapín II	Chapín II	Manzanillo	Manzanillo	San Vicente	San Vicente	Maximum limit
N°. sample	I	III/V	I	II/III/V	I	III/V	I	III/V	TULSMA*
pH	7,5	s/d	7,2	s/d	6,9	s/d	7,5	s/d	6 – 9
Conductivity µS/cm	6280	6120	3820	3090	2430	1931	2290	1878	N/A
Dissolved solids mg/L	3454	s/d	2101	s/d	1336	s/d	1260	s/d	500
Total hardness mg/L	578	s/d	488	s/d	179	s/d	173	s/d	500
Dissolved oxygen mg/L	7,1	s/d	7,1	s/d	6,2	s/d	7,6	s/d	6
Chloride mg/L	1379	s/d	762	s/d	493	s/d	458	s/d	250
Phosphate mg/L	0,24	0,5	0,4	0,73	0,45	0,7	0,53	0,9	N/A
Chemical oxygen demand mg/L	14	30	18	3	10	5	3	N/D	N/A
Calcium mg/L	101	107	110	74	27	24	24	29	N/A
Strontium mg/L	1,4	1,7	1,0	0,87	0,21	0,17	0,17	0,19	N/A
Manganese mg/L	0,064	0,078	0,77	0,089	0,0029	N/D	N/D	N/D	0,1
Potassium mg/L	49	63	30	25	25	22	20	24	N/A
Sodium mg/L	820	1265	458	358	338	293	290	307	200

*MAE, 2003. Unified Text of Secondary Environmental Legislation of the Ministry of the Environment (TULSMA – Spanish acronym).

Table 2. Results of the analysis of fecal coliforms (MPN / 100mL) at water sources between the months of May-July 2013 (ND = not detected).

Sample	Chapín I	Chapín II	San Vicente	Manzanillo
I	ND	90	ND	ND
III	9,2	2,2	2,2	ND
V	ND	1,1	1,1	2,2

Some crevices on the island are used as a source of water for homes. The crevice located near the municipal and Governing Council workshops is used by 10 families. Presence of fecal coliform, mercury, and TPH was detected in this water source. TPH levels were 600 times above the norm set by INEN. The amount of mercury was above the established limit due to improper practices for managing paints and fuels in the workshops.

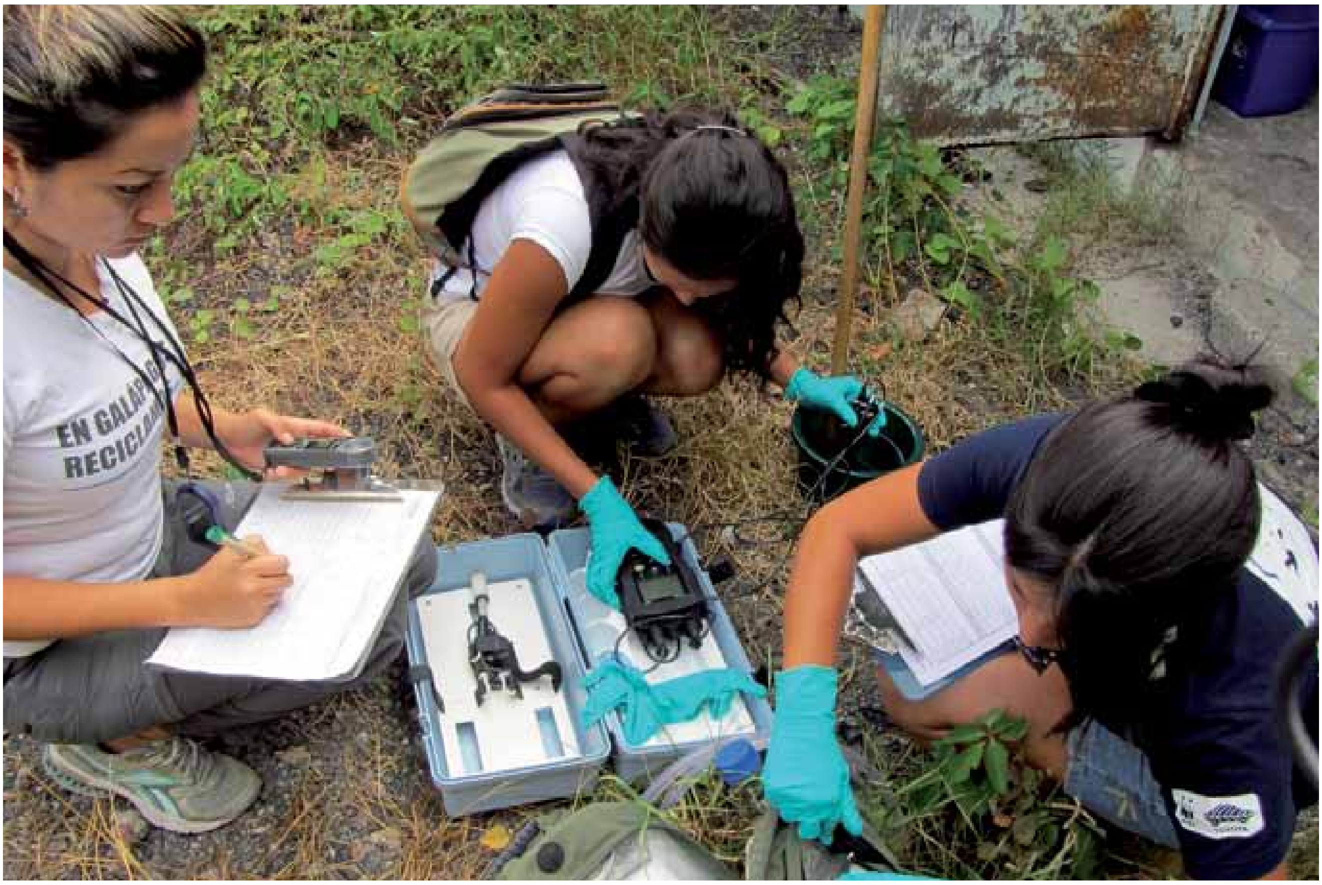
Levels of aluminum, copper, and mercury at the Embarcadero were above established limits, due to ship maintenance activities. The level of phosphates and nitrates at the Concha de Perla visitor site and the point of occasional wastewater discharge into the ocean was above the established limits set by the government of Queensland in Australia (Queensland Government, 2009). Phosphate-induced algae growth was confirmed by positive chlorophyll analyses at the point of wastewater discharge. Cesium (a radioactive element) was found to exist above the established limits in the water of Concha de Perla. The origin of this compound in the water is unknown; it could be the result of either natural or anthropogenic causes.

Soil quality

The results of the soil analyses show that copper, total chromium, nickel, molybdenum, lead, and zinc exceeded concentration limits at the workshops, power plant, and gas station. These compounds are present in a variety of anti-corrosive products, lacquers, paints, and fuels, all of which are commonly used at these sites. The presence of TPH in the soil is caused by improper handling of fuels. However, the presence of hydrocarbons at Estero and the Embarcadero requires a more detailed analysis as it could be due biogenic emissions (Campanioni *et al.*, 2007).

Air quality

The results of the air quality monitoring suggest that there are no air quality problems in Puerto Villamil.



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Recommendations

In terms of water resources we recommend:

- Use the water of the catchments Manzanillo and San Vicente for distribution via pipes to the public water system, due to the poor water quality of the water sources Chapín I and II.
- Build a new sewage system in Puerto Villamil. The current system is in poor condition and is potentially contaminating piped water used in houses.
- Regulate activities in the workshops to prevent pollution by hydrocarbons in nearby crevices.
- Regulate collection of used motor oil.
- Treat wastewater to prevent direct discharge into the ocean and prohibit the maintenance of boats in the sector of the Embarcadero.
- Install grease traps in restaurants in the central part of Puerto Villamil to reduce pollution from used vegetable oil.
- Conduct an in-depth study on the origin of cesium in the water at Concha de Perla.

In terms of the soil resource we recommend:

- Regulate the entry of lead-based paints and lacquers into the island.
- Rehabilitate the workshop facilities according to regulations in order to prevent the direct disposal of paints, lacquers, and fuels into the ground.
- Conduct more in-depth studies on the origin of hydrocarbons in sediments at Estero and the Embarcadero.

In order to improve overall environmental quality, we recommend the implementation of the Environmental Management Plan presented to GADMI authorities. This plan outlines prevention, control, and mitigation measures that must be initiated; a year-long monitoring of the environmental matrices; and the development of a manual of monitoring protocols and interpretation of results.

TULSMA is the legal regulation that defines the maximum levels of contaminants; however, it is a very general law and in several respects is inappropriate for the special conditions of Galapagos, which require stricter limits. It is essential to develop Galapagos-specific regulations that take into account human interactions with the ecosystem.

References

Campanioni E, A Clemente, M Medina, M Rodríguez, L González & R Marbot. 2011. Hidrocarburos antropogénicos en sedimentos del litoral nordeste de La Habana. Ciencias Marinas 227:235.

Córdova D, J Medina & Y Nagahama. 2007a. Monitoreo de calidad del agua en la Isla San Cristóbal. 18 pp.

Córdova D, J Medina & Y Nagahama. 2007b. Monitoreo de calidad del agua en la Isla Santa Cruz. 18 pp.

DPNG (Dirección del Parque Nacional Galapagos). 2014. Plan de Manejo de las Áreas Protegidas de Galapagos para el Buen Vivir. Puerto Ayora, Galápagos, Ecuador.

GADMI. 2010. Plan de Desarrollo Cantonal Isabela al 2020. Puerto Villamil, Galápagos. 39 pp.

INEC. 2001. Censo de Población y Vivienda 2001. Instituto Nacional de Estadísticas y Censos. Quito-Ecuador.

INEC. 2010. Censo de Población y Vivienda 2010. Instituto Nacional de Estadísticas y Censos.Quito-Ecuador.

Lenntech. 2013. Water treatment solutions – fósforo. http://www.lenntech.es/periodica/elementos/p.htm. Visited 26 August 2013.

OMS. 2006. Guías para la validad del agua potable. Organización Mundial de la Salud.

Queensland Government. 2009. Queensland water quality guidelines. Department of Environment and Heritage Protection.

MAE (Ministerio de Ambiente de Ecuador). 2003. Texto Unificado de Legislación Secundaria del Ministerio de Ambiente. Libro VI Anexo 1. Quito, Ecuador. 15 pp..

MAE (Ministerio de Ambiente de Ecuador). 2012. Acuerdo Ministerial 142. Registro Oficial Nº 856. Quito, Ecuador.

Walsh S, A McCleary, B Heumann, L Brewington, E Raczkowski & C Mena. 2010. Community expansion and infraestructure development: Implications for human health and environmental quality in the Galápagos Islands of Ecuador.Journal of Latin American Geography 9(3):137-159.