# Fresh water: the reality of a critical resource

Noémi d'Ozouville

Pierre and Marie Curie University, Paris, France, collaborating with INGALA

Although fresh water is not very visible in Galapagos, it is found in several places (underground, crevices, and streambeds) and is indispensable for all forms of life. Historically, Galapagos residents barely survived, having to search for water (rainwater, brackish water, and springs). Now they are part of a water supply system and pay for their water. However, when they don't know where the resource comes from, they don't take responsibility for preserving it.

> Currently, water resource users do not know where the water comes from nor do they take responsibility for preserving it.

**Table 1.** Definition of terms related to water resources.

| |
|---|
| **FRESH WATER:** Water in a natural state that is part of the water cycle: rain, lakes, streams, underground water. |
| ***Water Resource:*** The **amount** of fresh water that can be sustainably used for human consumption and use. |
| ***Domestic water supply:*** Water used for all household chores (bathing, cooking, etc.) |
| ***Potable Water:*** Water suited for human consumption according to health standards. |
| ***Irrigation water:*** Water used by the agricultural sector to water crops and livestock. |
| ***Sewage water:*** The "black water" returning to the environment after having been used for human consumption and use. There are various forms of treatment and disposal of sewage water. |
| **POLLUTION / CONTAMINATION:** The process affecting water **quality** with contaminants such as salt water, pesticides, oils, and fecal coliform (human feces). It is not always possible to remedy the problem. |
| ***Contaminated water:*** Natural fresh water, whether for human consumption or other uses, that is altered from its natural state and poses risks for health or the environment. |
| **User:** Person who pays for a service such as water from a tank truck or from a water supply system. |
| **Survival / subsistence:** State in which one's foremost concern is to satisfy one's basic needs to live. |

## Hydrological conditions in Galapagos

The **water entering the hydrological cycle** varies from year to year. The availability of water is particularly important for the agricultural sector. Water resources include rain and "garúa" (a thick mist that dominates the highlands during the cool season). The abundance of water varies greatly from exceptionally rainy years (El Niño) to years of severe drought (La Niña).

The **outlets from the hydrological cycle** are:

**(i)** Evaporation, which is quite high in winter and low in the garúa season in the highland areas;

**(ii)** Infiltration, which occurs rapidly because the soils are highly permeable;

**(iii)** Springs, both non-perennial springs fed by exceptionally heavy rainfall and permanent springs fed by underground water sources.

Fresh water in Galapagos is found in the following forms (Table 2):

- **Coastal lagoons and ocean inlets:**
  This water is less useful as a resource because the lagoons and inlets are vulnerable and readily affected by changes in watersheds.

- **Underground water in aquifers:**
  This is the fresh water that "floats" in equilibrium above sea water and is found beneath the surface of an island where the sea water has penetrated. An aquifer exists on all the islands. In the case of Santa Cruz, it is known that it is not very thick. This is a very fragile resource because it can quickly be contaminated by substances entering through the crevices in the Earth's surface.

- **Ponds, lakes, and wetlands (perennial or temporary):**
  These ecosystems are very important from a hydrological standpoint because of their role in water collection and storage for both the flora and fauna. Located in the more humid areas of the islands, they could be the optimal areas for infiltration.

- **Springs and streams:**
  Except for San Cristóbal, where there is a permanent surface spring that has been studied continually during 2006, the islands have little surface water. Springs have very low flow rates and streams run sporadically. Nevertheless, they are an important resource. However, because they flow on the surface, they are exposed to a high risk of direct contamination. They also depend on climatic conditions and underground storage.

- **Underground water in the highlands:**
  The lack of current data on underground water in the highlands makes it difficult to make the proper management decisions. While this type of resource might exist on other islands, only San Cristóbal is identified as having underground water resources. Their protection requires the protection of springs and streams.

> Inhabited areas in Galapagos were settled and have grown significantly with little thought to integrated water management.

**Table 2.** Parameters and characteristics of the forms of water present in Galapagos and an appraisal.

| FORM OF THE WATER RESOURCE | CHARACTERISTICS | | | | |
|---|---|---|---|---|---|
| | Importance for utilization | Sensitivity to changes | Abundance | Risk of contamination | Requires protection and monitoring |
| Coastal lagoons and ocean inlets | - | +++ | ++ | ++ | +++ |
| Underground water in aquifers | ++++ | ++ | ++ | ++++ | ++++ |
| Ponds, lakes and wetlands | - | +++ | + | ++ | +++ |
| Springs and streams | +++ | +++ | + | +++ | +++ |
| Underground water in the highlands | ? | + | ? | + | +++ |

**Note**

The symbols indicate the strength and direction of the relationship between each water resource and the stated characteristic. The plus symbol (+) indicates a positive relationship and the minus symbol (-) a negative relationship. The strength of the relationship is expressed by the quantity of symbols.

## Water resource issues in Galapagos

Fresh water is a dynamic resource. Inhabited areas in Galapagos were established and have grown significantly with little thought to integrated water management. Rainfall, runoff, brackish water, contamination, pollution, the agricultural zone, and the National Park are components of the same water cycle, yet the interrelationships are not fully understood. Water resources and scarcity are critical issues on the different islands (Table 3). Prices of water in 2006 can be used as a guide for future monitoring (Table 4).

**Table 3.** The critical situation of fresh water sources on the inhabited islands, 2006.

| USE | Santa Cruz | San Cristóbal | Isabela | Floreana |
|---|---|---|---|---|
| **Domestic in urban zones** | Municipal system – water from crevices and deep wells (not contaminated) | Municipal system - water from a stream (not El Junco Lake) | Municipal system – water from wells | Rainwater, spring |
| | Contaminated source (salt and fecal coliform) | Contamination beginning; leakage causes scarcity | Brackish, contaminated | Drought – lack of rain, the spring dries up |
| **Domestic in rural zones** | Rainwater | Rainwater, streams | Rainwater | Spring, rainwater |
| | Drought | Some streambeds are affected by drought | Drought | Drought |
| **Potable Water** | Private desalination plants; rainwater | Private desalination plants; rainwater | Imported drinking water; rainwater | Imported drinking water; rainwater |
| **Water for agriculture** | Rainwater, tank trucks – salty, contaminated water | Rainwater, streams | Rainwater, tank trucks – brackish, contaminated water | Rainwater - drought |

**Table 4.** Prices of water resources in Santa Cruz.

| Type of water | Unit price |
|---|---|
| Contaminated water from the Municipal system, domestic use | $3.00 per month |
| Contaminated water from the Municipal system, commercial use | $8.00 per month |
| Water from the deep well supplied to Bellavista with meters | $1.21 per $m^3$ |
| Contaminated water supplied by tank trucks, highlands | $10 - $30 per $m^3$ |
| Desalinated water | $100 (in jugs) per $m^3$<br>$25 (from a hose) per $m^3$ |

For domestic use, the most serious problems are contamination, which affects water **quality** (Santa Cruz), and losses due to leakage, which results in **scarcity** of water (San Cristóbal).

The major problem for the agricultural sector, except on San Cristóbal, is the lack of fresh water and the need to purchase brackish water.

## In summary:

- **Santa Cruz** has very poor underground water quality on its coast due to contamination. Irrigation water is in short supply for farmers and there is a lack of sufficient knowledge of the aquifer to manage it on a sustainable basis. It is necessary to seek alternatives.
- **San Cristóbal** has abundant water in the highlands but it does not reach the population. The distribution system is complex and requires better management. A simple treatment system for stream water is needed. It is also essential to establish a flow-rate monitoring system to provide information to decision-makers in the event of a drought.
- **Isabela** has problems with contamination of coastal sources due to an increase of salt and fecal coliform. It also lacks water in the highlands.
- **Floreana** has depleted its springs and there is a total lack of water for its population.

## Research results and recommendations

### JICA-GNPS Program – water quality monitoring in Santa Cruz[1]

Monthly monitoring of 11 land sites and 9 marine sites has been conducted to track contamination. The monitoring includes assessment of several parameters to determine water quality, such as oils and greases, fecal coliform, detergents, mercury, lead, and hydrogen potential (alkalinity), among others. These values are then compared with the maximum allowable limits.

In the case of water resources distributed to the human population, the level of fecal coliform is particularly important. Monitoring results in 2005 indicate very high levels of coliform bacteria in the crevices of Puerto Ayora: 100 to over 10,000 nmp/ml, depending on the month and site. The maximum allowable limit for total coliform bacteria is 600 nmp/ml. In all sites sampled, the highest levels of fecal coliform were recorded in November and December. It is extremely important to continue this monitoring because contamination levels affect water quality and cause health problems. This contamination could be reduced with the support and participation of Galapagos residents.

**Recommendation:** Monitor all water sites used for human consumption and in zones of the Park (because of the effect on ecosystems) and monitor water that is desalinated by small private companies that use contaminated brackish water for conversion to potable water.

### Hydrological-hydrogeological project of Galapagos[a] - University of Paris-6 in collaboration with the GNP, CDF, INGALA and Municipalities[2]

The goal of this project is to understand how the hydrological cycle works in Santa Cruz and San Cristóbal.

**Santa Cruz:** Four pressure probes measure hourly variation in the water level in the deep well of three crevices, two of which are used for water supply and one which is not.

Data show that tidal variations influence water levels for a period of time that can range from a few hours (in the crevices closest to the ocean) to 42 hours in the case of the deep well. These variations also affect the electrical conductivity of the water at these sites. It is important to monitor increases in electrical conductivity in the deep well because a continued increase could be attributed to saline intrusion, which could affect water quality. The probe in El Chato Lake revealed that the lake level dropped gradually from late March 2005 until it dried up that October. The lake's water level has not yet recovered. Non-perennial springs are being monitored in relation to rainfall. The study also delimited the watersheds.

**Recommendation:** The concept of managing by watersheds is used more and more extensively worldwide and should be applied in Galapagos. For example, the watershed encompassing Cerro Crocker and Puerto Ayora includes the nesting zone of endemic species in the Park, two urban areas, and one agricultural area. It is also a region where concentrations of rainfall during El Niño periods can cause serious damage. Watershed management should involve all the authorities who have responsibilities over these zones.

**San Cristóbal:** The very dry climatic conditions in 2005 and early 2006 have reduced the level of El Junco Lake and river flow rates on this island (both monitored under the project). The level of El Junco Lake fluctuates according to climatic variations. However, it **is not** a source of water for the human population.

**Recommendation:** It is important to protect the lake's perimeter to ensure maximum recharging during both the garúa and the rainy seasons. The decrease in stream flow affects some tributaries, which become permanently dry. However, the fact that the four rivers leading to the sea continue carrying water to the ocean during drought periods means that they are fed not only by rainfall, but also by underground reserves.

> Each island has its own water needs and priorities, but the most serious problems are the same on all islands: pollution, waste, and scarcity of fresh water.

[a] The hydroclimatic data compiled and analyzed under the project will appear in the doctoral thesis of Noémi d'Ozouville and in scientific publications.

The concept of managing by watersheds is used more and more extensively worldwide and should be applied in Galapagos.

## Seeking an overall solution

The year 2006 has been marked by several events that affirm national and international support for changing the current situation in Galapagos and seeking comprehensive and integrated solutions. To address water issues in Galapagos it is important to work simultaneously on:

(1) **Technical and scientific information.** A project, begun in 2003, is focused on understanding how the hydrological cycle works, determining the resources available, and evaluating the dynamics among them. This collaborative project was developed by Pierre and Marie Curie University in France, the GNP, the CDF, INGALA, and the Municipalities[3]. In 2006, this project mounted a geophysical study of Santa Cruz and San Cristóbal by helicopter to investigate the presence of underground resources.

(2) **Citizen participation.** In May 2006, a local NGO (FUNDAR),[4] in conjunction with Paris 6 University, held a panel discussion entitled "Fresh Water in Galapagos: A resource to rediscover." Presentations on international and national experiences were followed by a debate on "how much water costs" and a participatory forum broadcast live on television.

(3) **Political advocacy.** In 2006, INGALA and CAMAREN held a provincial working group on water resources involving the various institutions that play a major role in water management to encourage policy reflection on this issue. This working group was fundamental in promoting the search for feasible solutions.

During the August 2006 Colloquium of Social Science for Galapagos, a literature review was presented[5] on past initiatives and a detailed presentation was made about the "social issues" of water in Galapagos. Implementation of a new Potable Water Project on the four inhabited islands is set to begin in 2007 and should be operational by 2008. The purpose of this project is to provide potable water through new systems in the four port towns. Desalination plants will be used on all islands except in Puerto Baquerizo Moreno in San Cristóbal where the water comes from streams in the highlands. Potentially, this project could solve the water supply problem in ports but **will not** solve problems related to: i) contamination of water sources; ii) supply for the agricultural sector (the cost will be too high to buy and transport desalinated water for agricultural use); iii) lack of social responsibility and a culture of water conservation; and iv) pollution from sewage. It is important to note that the current price of water does not represent its real cost for production, distribution, and treatment.

Without an integrated fresh water management plan for both urban and rural areas that addresses potable water contamination and treatment, and unless users assume their social responsibility, the situation will only get worse. Until now, the gap in knowledge about hydrological systems in Galapagos has been an obstacle to integrated management of ecosystems and implementation of adequate water systems. To fill this gap, it is necessary to carefully consider the relationships among fresh water, water resources, potable water, sewage water, and environmental pollution.

An integrated fresh water management plan is needed. It must involve urban and rural sectors, issues of contamination and treatment of potable water, and, above all, citizen responsibility.