

Informal Settlements and Wastewater Reuse: Improve of Urban Environment and Alleviate Poverty in Lima, Peru

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1 Introduction

The city of Lima, capital of Peru, is located on the Coast of the Pacific Ocean and has a current population of about 8 million. Lima is and has been the principal cultural, political and economic center of Peru.

Since 1940 people from the highlands and jungle have been immigrated to Lima. They came in search of better living conditions and education. The city of Lima includes several urban shanty-towns. Because these communities emerge in informal ways, they often lack basic public services such as safe water supply, wastewater collectors and waste services. Old, small buses serve for public transport; electricity service is available in 90 % of the informal settlements. Income rates lays in the range of 27 to 62 €/ month.

Ministry of Housing, Infrastructure and Sanitation (2006) states that Lima generates around 16.5 m³ / s of wastewater, the major part of which is discharged untreated directly to the River Rimac or into the coastal marine waters. Beaches along the Pacific Coast are polluted by industrial waste and contaminated by human pathogens. Nevertheless, people go to those areas for recreational activities, thus the rate of infections and skin diseases is high.

Peru is a country that needs to improve its infrastructure to provide better living conditions for people. Webb and Fernandez Baca (2007) state that about 6.5 mill. inhabitants in Peru need safe water and sanitation services: 1.8 mill. live in the urban area and 4.7 mill. live in the rural area. In Lima, 1.2 mill. individuals lack sewer service. The required investment in infrastructure to overcome this deficit is approximately around \$ 3,500 mill.

The Ministry of Housing, Construction and Sanitation and SEDAPAL, the Water and Sewer Supply Company for Lima, developed a National Plan of Sanitation with the aim of providing safe water for all. SEDAPAL is planning to invest around US\$ 1,400 mill. until 2011. The projects include a dam to collect water, a new drinking water treatment plant, and two wastewater treatment plants. All the

projects will be fund with private participation. The financial amount of private participation is supposed to be around US\$ 700 mill.

Due to this situation and its development in the near future other alternatives are need. The reuse of treated wastewater in urban agriculture and green areas in a city like Lima located within a dessert can improve landscapes, environment, and living conditions. Plants and trees can protect from the erosion and absorb pollutant. Green areas create a clean and pleasant atmosphere within the city. When integrating urban agriculture (based on irrigation and fertilization by products from wastewater) jobs can be provided. People involved can get access to fresh vegetables and extra income when they sell the products at the market. Additionally, as women are the driving forces regarding family health, a major impact and increase is possible also in this area. Hence, an adequate urban agriculture and with integrated handling of wastewater can reduce diseases and improve the living condition especially for children and other vulnerable groups.

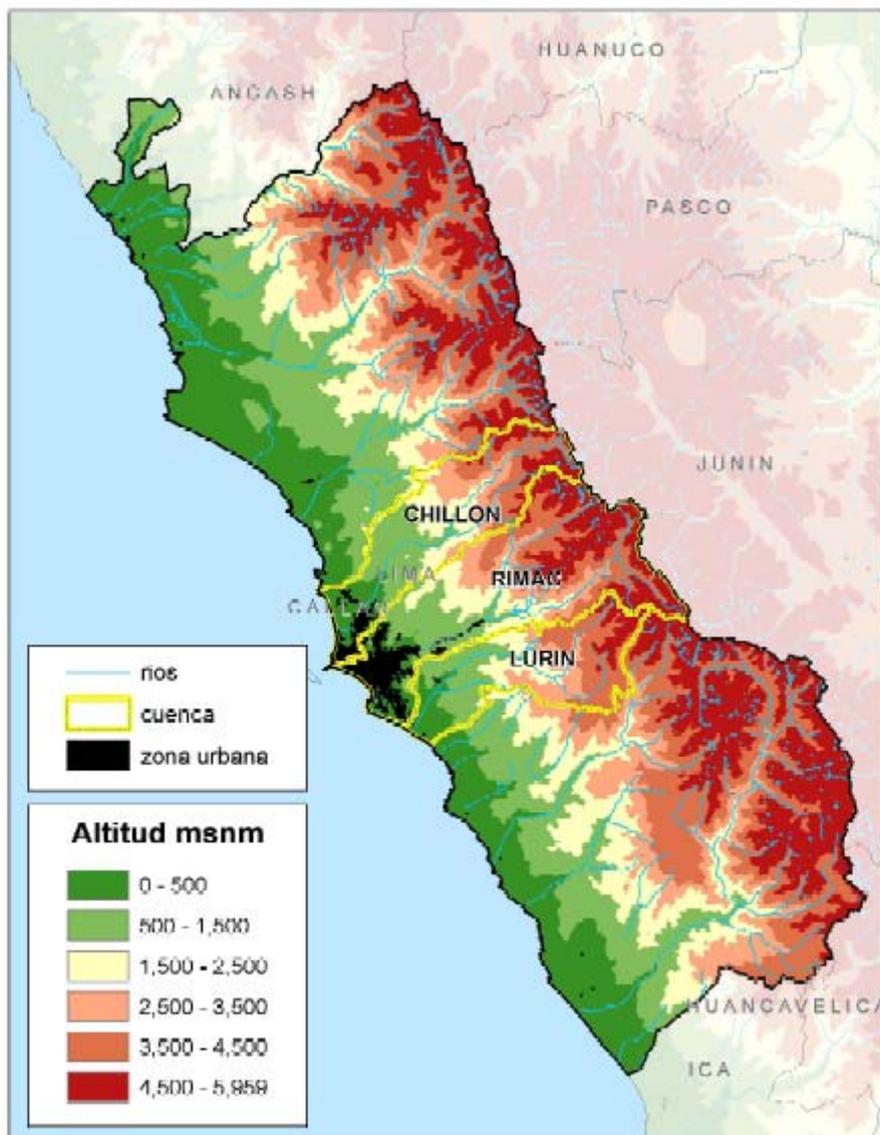


Figure 1: Lima and its principal rivers (Brack Eggs, A. and C. Mendiola, 2004).

2 Water supply

Three rivers surround Lima: River Chillón in the North, River Lurín in the South and River Rimac. The city was originally built along the borders of River Rimac and it is still of main importance for the city.

The Rimac River Basin runs from the Andes Mountains in the East to the Pacific Ocean in the West. The area of the basin is the most densely populated region in Peru. Within the extensive river basin exist urban centers, extensive agricultural areas, mines, informal settlements and factories. All of these use the river as a water source and also as discharge.

Because of extensive use of the river water, the River Rimac is almost dry before reaching the sea. However, River Rimac cannot provide water for the whole population of Lima. Therefore 30 % of the water for covering the water demand comes from wells. Because of this, a reduction of underground water could be observed in the last years. As a consequence the groundwater system is increasingly polluted by salinity since the water table near the ocean drops because of increased pumping especially in the dry season.

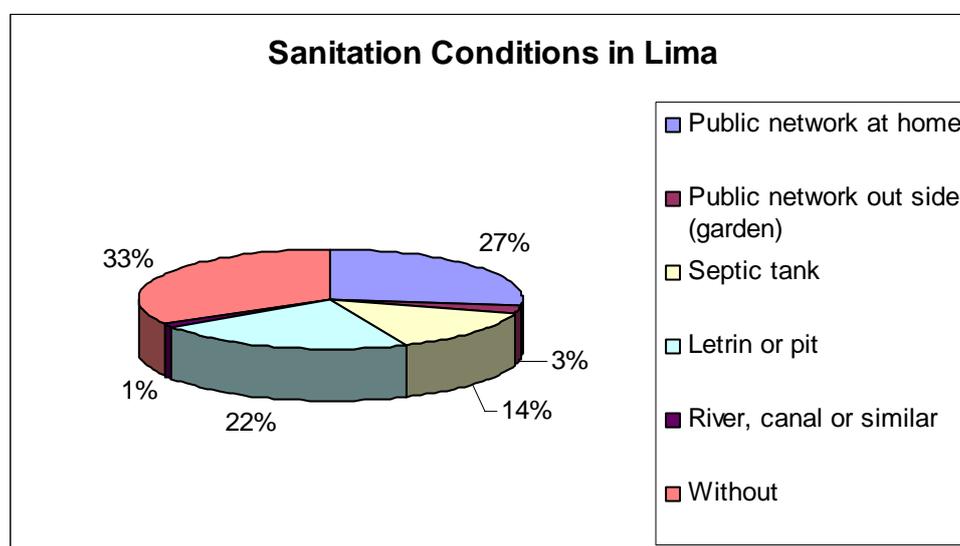


Figure 2: Sanitation Conditions in Lima.
Type of sanitation available (based on Cuanto, 2007).

3 Sanitation

The situation of sanitation in Lima is related to the development of the city. In the traditional districts around 90 % of households are connected to the conventional system, receive good quality of water. General conditions of functionality are good. In a second group of districts around 60 % of households are connected and receive good quality of water but only some hours a day. Sewer connections are less. Finally, in informal settlements people have to manage to get water from private water vendors and live without an infrastructure to collect wastewater.

SEDAPAL provides the service of collecting and treatment of wastewater in 14 WWTPs in Lima. Three of these are located in the South. Treated wastewater is reused to irrigate parks and agricultural fields.

Despite the number of treatment plants SEDAPAL only treats 4 % of the overall wastewater. On the other side Municipalities of this city lying in the desert are interested in using treated wastewater for irrigation of parks and gardens.

Government investment in the last decades could not achieve the rate to provide the whole population with the basic services. New technologies (low cost and decentralised) and community participation in their own development can improve the conditions in these less developed areas of the city. Ministry of Housing (2006) states that new sanitation plans are designed to carry out a system that involves municipalities, SEDAPAL, and communities to have even more treatment plants in the city and thereafter reuse the treated wastewater to irrigate parks and green areas

4 Sanitary alternatives for informal settlements

4.1 ECOSAN projects

CENCA - the Urban Development Institute - has promoted ECOSAN since 1997 in Peru as a strategy to solve problems in health and sanitation. First they made experiments and later pilot projects that have begun to impact the users and have also been adopted and implemented by other non-governmental institutions.



Figure 3 a & b: ECOSAN facilities in Lima.

Since 1998, CENCA implemented in the district of San Juan de Lurigancho, 48 ecological toilets in individual homes and an irrigation system for 700 m² of green area. Since then, an additional project including 55 ecological toilets has been implemented in other regions and the treated wastewater is used to irrigate trees. CENCA has also consulted with other groups who have implemented ecological toilets in institutions and households in Peru.

Two main systems are implemented in the ECOSAN projects in Lima:

- **A domestic system** located entirely in the house. The system includes the complete bathroom, a laundry, and a collector network of grey water that ends at a settling and flotation tank that retains fats and suspended solids. This tank is connected by a channel to the local system.

- **A neighborhood system** with a collector network (called ECODESS). By this the water coming from all units is collected and transported in channels to a filter before storage in a cistern. The cistern is supplying an underground irrigation network to maintain green areas. ECODESS re-uses grey waters in urban irrigation thus avoid using portable water for irrigation purposes.

4.2 Greywater separation and reuse in Parks and Gardens

A project from ECOCIUDAD - Institute for an Ecological City - was implemented and includes 100 houses. ECOCIUDAD worked together with SEDAPAL, and private companies (a producer of ceramics and bath accessories) to implement this project.

66 houses were equipped with a toilet, shower and a laundry. Blackwater from toilets is discharged into the conventional system (provide by SEDAPAL) and grey water is treated in constructed wetlands.



Figure 4: Project in Villa Salvador implemented by ECOCIUDAD (2006)

4.3 Wastewater treatment ponds

Another alternative system to reuse treated wastewater in Lima was implemented by the NGO Urban Harvest. The project was based on the fact, that in the East part of the city people are likely to be part time farmers (48 %). At the same time 45 % of men do commute temporally outside the area in search of work. Because of high increase of the population in this area, every day a new house is set up. Thus, in the last two years 30 % of land changed from a farm to house. However, farming style persists and is mainly characterized by mixed cropping of vegetables. Farm plots are similar in size and planted with vegetables such as beets, lettuce, turnip, radish and herbs, mainly for commercial sale, while raising livestock is practiced for family consumption and for sale.

Arce and Prain (2004) state that farmers did not highlight water scarcity as a constraint but the water quality. Increasing urban pollution and environmental contamination result in their canals filled with garbage and pollutants threatening the safe feed of their families.

Urban Harvest carries out different projects to control the pollution in their principal canal, called Carapongo. The system implemented to control pollution is based on ponds. After a residence time of around 4 weeks in the ponds farmers can use the water to irrigate crops.

Arce (2007) states water quality is now between the standards indicated by the General Law for Water. Urban Harvest is waiting for a control of Ministry of Health to continue with this project and build new ponds in the area.



Figure 5: Ponds in Carapongo, Lima.

5 Urban Agriculture and Green Areas

5.1 Farmers

In the Northern area of Lima, more than 2,600 inhabitants are involved in agriculture. For irrigation water from River Rimac and also untreated wastewater from SEDAPAL sewer system is used.

During the dry season wastewater is the only inexpensive source. Additionally the wastewater is used as a source of nutrients. Wastewater is channelled to the farming land and in some cases carried to the fields in watering cans. Moscoso (2002) states that 690 ha are irrigated with wastewater and this area is planted with vegetables as celery, spring onion, onions, tomato, and garlic. Farmers sell these vegetables at the principal markets in Lima.

In the South of the city, the Municipality of Villa El Salvador in its urban planning design reserved an area (more than 300 ha) for the use of agricultural fields. Currently, in “Zona Agropecuaria Villa El Salvador” farmers plant crops, animal fodders, corn, yellow corn, Lucerne, fruit trees and flowers.

This area is the only agricultural area in Lima with an irrigation system relying on treated wastewater. Three plants run by SEDAPAL provide treated wastewater for these areas. However, currently there is a strong pressure from new migrants that want to set up new houses in this area.

Farmers use a flood/furrow irrigation technique. For the use of wastewater for irrigation some precautions have to be fulfilled. E.g. following the General Law for Water (1970) farmers have to maintain a buffer zone of 50-100 meter from houses or roads to prevent health risks to local communities. Farmers and people involved in agriculture in the North and South of Lima are affected by different situations like industrial effluents mixed in wastewater, land tenure system, lack of infrastructure to process the products and a weak legal framework.

5.2 Irrigation of Parks and Gardens

Lima is a city in the desert without many green spaces. Parks and green areas are managed and maintained by municipalities. Water is an expensive input because it has to be transported from wells or canals to those areas. During the dry season, also the municipality has also to buy water from SEDAPAL to cover the water demand.

Around 1400 ha in Lima are covered by parks and gardens. However, this is not fulfilling WHO recommendations for a large city like Lima, which is stating at least 8 m² per inhabitant in big cities. Lima needs reach 4700 ha of green areas (parks and gardens) to be a healthy city.

5.3 Gardens and orchards in informal settlements

In informal settlements people run community gardens to produce vegetables (i.e. lettuces, onions, cabbages, etc.) for popular kitchens. This activity involves unemployed people and women mainly. Their products allow that children and old people can get fresh vegetables. People that produce the vegetables have an extra income to support their families.

IPES - Institute to Promote Sustainable Development - carries out a project in Villa Maria del Triunfo where IPES works together with the Municipality of Villa Maria del Triunfo, mothers and unemployed people and Electro Sur, the utility company for electricity.

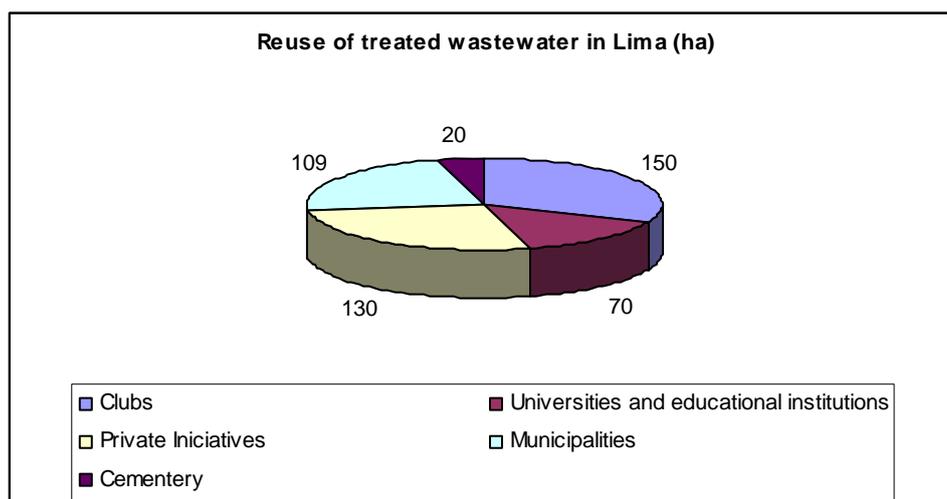


Figure 6: Reuse of treated wastewater to irrigate gardens and parks

5.4 Private

Some organizations and institutions have facilities to treat or recycle wastewater, since there are no other alternative sources of water within the city and otherwise costly drinking water has to be used also for irrigation of garden and game fields.

Main universities and some secondary schools like College La Inmaculada and the main cemetery in the city reuse treated wastewater to irrigate their green areas. They take wastewater from SEDAPAL sewer system and treated it in a system of ponds and channels. Clubs recycled greywater from showers and laundries to irrigate golf courses. Moreover, the Municipality of Surco runs a treatment plant and reuses the treated water to irrigate parks and green areas. Also SEDAPAL reuses treated wastewater to irrigate areas in the East part of the city.

All of this is part of an environmental responsibility. In some cases awards could be achieved in some events related to environmental activities carried out for NGOs.

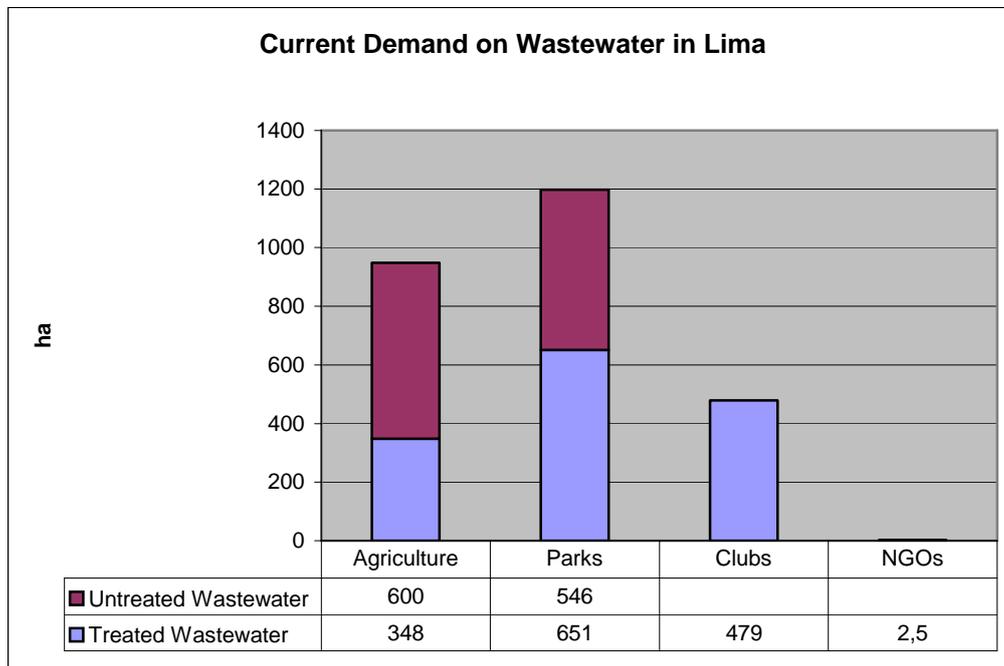


Figure 7: Current demand on treated and untreated wastewater in Lima

6 Potential for linking urban agriculture and wastewater

Treated and untreated wastewater, as state above, is used for crop production, which includes fodder grasses, vegetables, ornamental plants, trees, timber crops and fruit trees. Wastewater users come from a wide range of socio economic backgrounds and have a variety of motivations to use wastewater for irrigation. For example, for farmers in the North area during the dry season wastewater is the only source of irrigation water. It is also an option for municipalities that can irrigate green areas and parks and for Urban Agriculture initiatives that can sell their products at local markets and to local customers.

A total of 2468 ha are irrigated in Lima with treated or untreated wastewater (See Figure 7) to produce vegetables and different crops and also large areas of the city are green only because there are near a channel that conduce water. It is important to notice that private initiatives use treated wastewater in their sport fields and also contribute to improve the environment of Lima a city in the desert.

6.1 Potential demand of wastewater in general

Wastewater use will be increased in the future, because, every day water from river is less as input for drinking water plants and green and agricultural areas in the city. Figure 8 shows the potential demand based on the land reserved to become parks and green areas as included in the urban planning program of Lima, a special program on Urban Agriculture supported by NGOs, SEDAPAL and private companies. In this figure the demand from other sectors like landscape architecture and estate development is not considered.

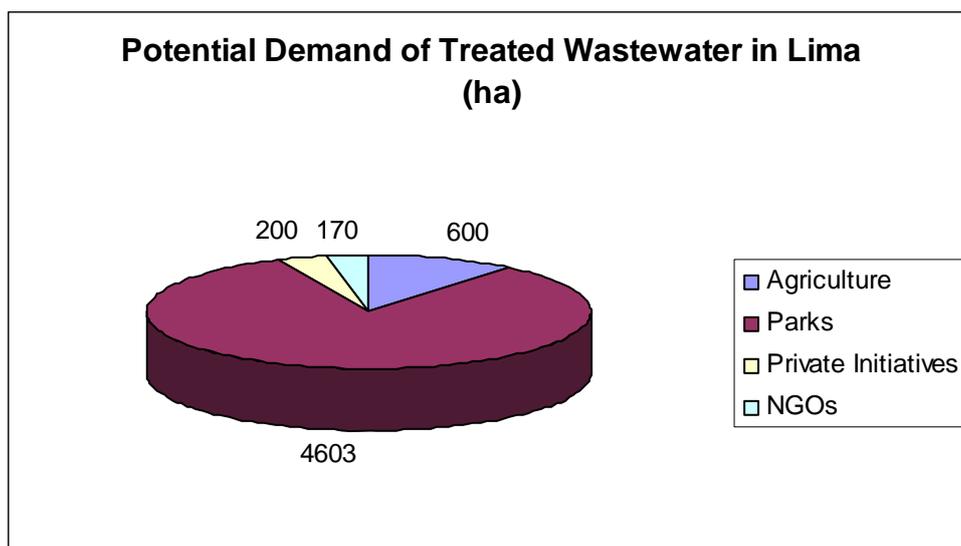


Figure 8: Potential Demand of treated wastewater in Lima

6.2 Potential demand for EcoSan

ECOSAN as a system that offer solution based in minimization of environment pollution, low cost technology and beneficial impacts in the health of people. ECOSAN is an option to improve situation of sanitation and there are different perspectives to consider how ECOSAN products can be implemented:

- a) ECOSAN can help, even without any market for the products from ECOSAN, to reduce the sanitation challenge and to save money. This is especially important in a country like Peru, where the government has not sufficient funds for building new treatment plants, while ECOSAN facilities could be set up in a decentralised design and by private initiatives. However, responsibilities for setting up and maintaining the facilities have to be clarified, whether municipalities or communities.
- b) ECOSAN products are valuable fertilizers and soil conditioners as they contain organic matter, nitrogen, phosphorus, potassium and other micro-nutrients. Some problems like the high content of pathogens can be managed: After a period of six months of storage urine can be use for fertilizing crops. Faeces can be converted by use of alkaline material and storage into dry material that can be further composted or directly spread onto agricultural fields. WSP (2006) state in a work carried out for CENCA that sanitation and health problems can be reduced when people use ECOSAN facilities.
- c) Management of wastewater is in general in hands of municipalities and other utility companies. However, ECOSAN can introduce a new frame to manage wastewater. Small enterprises can be implemented following communal waste management. Monge (2004) states that in Peru small enterprises collect and process garbage from informal settlements in different cities. Living conditions for people who manage the enterprises can improve because they have jobs and a regular income. Moreover, the community in general benefits from this service that the municipality or local government cannot offer.
- d) ECOSAN can be a source of saving costs for the city because is not necessary to build huge sewer system and treatment plants to serve people. Especially in areas without broad roads and with hills and small spaces to store materials ECOSAN can be implemented.

- e) Farmers as potential buyers of wastewater products generally have a positive perception towards wastewater integration into agriculture. Their main concern is a sufficient fertility effect and avoiding soil amelioration. Additionally, they are interested in alternative fertilizers. However, manures can be in competition with ECOSAN products when it is abundant and free in particular areas¹.

7 Conclusion

The analysis of the current situation in Lima shows that there exist problems regarding wastewater management in the city, but several strategies and alternative technologies exist to reduce the impact in the health and living conditions of the people.

Politicians, government officers, and citizens express that they want a green city and an adequate management and reuse of wastewater which offers possibilities for a greener city. However, they do not know enough about the potentials of reusing wastewater within the city or implementing alternative wastewater concepts like Ecosan.

Nevertheless, some projects implemented by CENCA, Urban Harvest and Ecociudad follow the principles of ECOSAN and can be seen as demonstration projects for further spreading. These projects have decentralised and cheaper treatment solutions. Treated wastewater is channelled and used in green areas and urban agriculture. Some results are that there are in the area, less health problems associated with raw wastewater application and its direct discharge into the environment. On the other side, local people increase their access to fresh and cheap food.

All of these projects are located in the borders of the city, area of poor people and improve quality of urban environment, with cultivated area of trees and crops that control soil erosion and lead through a proper management to soil enrichment.

Although, reuse of wastewater in agriculture and green areas does exist, it is a problem in terms of health and quality of products. It is necessary the different measures of the legal framework and today's practices are improved. Then more than 5000 ha can be green and safe within the city.

More than 1.2 millions of inhabitants need an appropriated sanitary system. A system like ECOSAN can help to reduce this situation because could be set up by the community, small enterprises can manage the storage and sell of the products. Groups of women and migrants involve in urban agriculture within informal settlements are potential customers for the ECOSAN products.

Socio-legal obstacles like non-recognition of reuse of wastewater and urban agriculture as a livelihood strategy, weak coordination among the different institutions should be taken into account when there is a plan to work linking wastewater management and urban agriculture.

8 Recommendations

Wastewater management in Lima can be improve, because is a social issue which is of the interest of government and citizens. A legal and social process has to be done to reach a better situation.

The legal framework has to be improved to meet the required guidelines regarding the management and treatment of wastewater for agriculture as well as for further ECOSAN products.

Academic seminars, media campaign and other strategies can be use to communicate and inform about treatment options and how they look like and work. Where the facilities and new technologies will be set up, a program to train and educate people should be implemented.

¹ Felipe Morales, Carmen (personal communication, Lima, March 2007)

Funds from different international programs and agencies are invested to promote and implement ECOSAN facilities currently supporting projects in small communities. Within SWITCH project is implemented a Learning Alliance, and IPES –Institute for Sustainable Development- is in coordination to get together stakeholders ideas and propose solutions for the future. This can be a first step for providing information and promote changes.

Some points should be priority to reach the implementation of ECOSAN options in Lima:

- Low cost technologies: The new technologies and regulations must be based on realistic and practical experiences in situ.
- Agriculture and selection of products/crops: A crucial point is to link treatment and use of treated wastewater. Government officers and farmers should select the appropriated crops or reuse of wastewater together or even better establish a classification scheme which wastewater product can be applied for which crops.
- The willingness to pay for ECOSAN products is not known because there are no studies done in Lima considering economic analysis. Studies should be carried out focusing on actual and potential users of ECOSAN products (especially in the different urban and peri urban farming systems) and their attitudes and perception toward the use of products originating from wastewater.
- Uses acceptance of ECOSAN technology. A survey should be completed to know which is the appropriate option for each group. This knowledge can help in the use and maintenance of facilities, because sometimes, people look ECOSAN as temporary system before conventional system arrives in their area.

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