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Resilient sanitation for settlements affected by water scarcity: A case study of Manabí, Ecuador

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Abstract: *Sanitation in Manabí is considered an unmet basic need, which despite the efforts of the various levels of Government to cover it, does not seem to have given significant advances. Conventional technology to give coverage to the population without access to this human right does not respond to the reality of the segment of the population who live in rural and marginal urban sectors. This picture doesn't get any better if we include in the analysis the vulnerability of that same technology to areas with water scarcity.Access to sanitation must be understood from the context in which the need was generated. Moreover, it states that the sewerage networks involve costly civil works; to implement this type of technology is not feasible, neither technically nor economically in human settlements for affected people. Without even mentioning the environmental impact it causes.*

Keywords -*Sanitation, scarcity, water,dry toilet*

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I. INTRODUCTION

In Ecuador we still haven´t stated alternative solutions for the treatment of excreta, despite the important deficiency in the access to sanitation services that still exists. According to INEC data the coverage of this service in Manabi reaches hardly 33% and it is estimated that it has stagnated around this value because of the hydric deficiency, thus worsening the critical water sanitation situation.

It is of vital importance to plan, design and build human settlements in disaster areas in an harmonic way with natural patterns and cycles. The success of these systems lies in establishing, through design, the maximum relation between all the elements or components of human settlements (system) to satisfy our needs and the needs of other forms of life that may inhabit the place.

The housing is at the middle of many changes from this point of view. Inside of it may be produced an important percentage of the food that a family in the world consumes. Likewise, with simple water separating systems we could reuse the resource without needing to eliminate it through the sewage, even more if these systems are vulnerable to drastic weather changes.

In the other hand, the low levels in the results of objective seven and the goal 10 of the Millenium Development Goals (MDG) indicates, the worsening of the human development, health and dignity indexes of the population. On this regard Schriber [2] affirms that the rhythm of accomplishments that these MDG left as a result, that 2,430 millions of people still remain without access to excrement disposal installations, furthermore, it states that basic sanitation constitutes an overdue debt with the world´s poorest.

In this sense, an innovative solution –quasirevolutionnary – to the sanitation crisis due to water deficit is: ecosanitation. As Cruz [3] States it is based in the principles of zero emissions and recycling of all its products, turning each of the residues into an useful material for agriculture, in an hygienically and safe manner and with a notable water saving, or even without using this resource.

The concept of ecological sanitation (EcoSan) may be interpretated as an integral proposal for the mangement, disposal and reuse of the human waste (fluid and solid) in rural and urban kitchen garden; thus preventing the pollution instead of solving it after producing.

The Panamerican Center of Sanitary Engineering and Environmental Sciences (CEPIS in Spanish) [4] considers ecological sanitation solution given to the absence of this service in different countries, particularly in dry areas. This technology arises due to the high costs implied in the construction of sewer networks and further treatment, which cost increase in places with disperse houses typical of rural communities.

1.1 MANABÍ AND ITS CONDITIONS

The province of Manabi, in normal circumstances, struggle with insufficient water supply; after an extreme event, this situation becomes critical. As Vivero [5] indicates the water balance in hydrographic systems –despite that global numbers and in sub basins are very positive– where there are zones with water deficit for up to nine months per year.

In the same document it is mentioned that "water deficitary basins are concentrated in two areas: the Manabi province (hydrographic systems of Jama, Portoviejo and Jipijapa) and to the south-east of the Guayaquil Gulf (Taura, Balao and Arenillas – Zaruma)". In the case of the Manabi province, the availability of water resources is not very far of the critical value of 2,000 m3/hab/año.If out of the basins mentioned in the previous paragraph, we select Portoviejo river one, where the capital city of Manabi is settled, we can establish that bioclimatically it is located in a region classified in the Holdridge scheme as sub-desertic tropical.

The previous statement is confirmed in the following table with multiannual years data, registrated by the National Institute of Meteorology and Hidrology (INAMHI in Spanish), since July 1st 1930.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Air temperature (°C)												
Maximum	34,5	34,0	36,0	34,4	34,1	33,1	33,1	33,0	34,9	34,0	34,9	34,8
Minimum	21,0	21,1	19,5	19,9	18,6	19,0	18,2	18,0	17,6	18,5	19,7	20,8
Average	26,1	26,5	26,5	26,5	25,0	24,8	24,0	24,0	24,1	24,5	25,0	25,5
Rainfall (mm)												
Total	105	120	103	59	30	26	14	4	5	3	6	16
RH (%)												
Máxima	99	100	100	98	100	98	96	96	96	95	95	97
Mínima	51	59	52	52	53	56	49	48	44	47	48	51
Media	80	87	82	80	79	80	77	78	75	76	74	75
Periodo de información: 64 años												

Table 1. Average monthly values of various years of temperature, precipitation and relative humidity.

As shown on "Table 1", the area is hot, reaching maximum temperatures of up to 36 °C. The annual precipitation values add up 491 mm, which are distributed unevenly. There is a significant rain decrease in the period marked between April and December, months during which occurs a third of the annual precipitation. The two remaining thirds correspond to the months of January, February and March.

Additionally to the fact that the precipitation in the zone is relatively scarce, an evaporation transpiration annual of 1,574.8 mm is registered. This combination expresses clearly the existence of a hydric deficit in the ecosystem.

Dicho esto, se vuelve inaceptable el uso de importantes volúmenes de agua potable para evacuar excretas humanas en las viviendas. Cruz [6] estima que se requieren 15,000 litros de agua por persona/año, para descargar 500 litros de orina y 35-50 kilogramos de heces. Estas aguas son descargadas en los cuerpos hídricos casi sin ningún tratamiento lo que deriva en la principal fuente de contaminación de agua dulce en la provincia.

From this perspective, the waste of our body rather than being disposed as waste shall be integrated into the habitat through processes different to the ones we know. This process includes agro-productive activities (home gardens), generation and saving energy, water and waste management, exchange of knowledge and resources, among many other aspects.

II. RESILIENT SANITATION: WHICH ONE?

There are many research documents pointing out that conventional sanitation system is unlikely to solve the problems of the developing countries. In fact, many studies assure that they don´t even represent a solution in developed countries.

The resilience of a system is given by the capacity of response to the needs generated in particular circumstances. Feaces and urine are body wastes which driven within an inadequate system can generate direct (diseases caused per pathogens) and indirect (food, recreative waters, bad odor) consequences for health. Besides it can provoque alteration to the ecosystem (eutrophication of superficial water courses) because of the deficient treatment of wastewater.

URINE	FEACES
Sterile	Host microorganisms
Low bacteria content	Highpathogens content (bacterias, virus, protozoa, helminths)
Low risk of disease transmission	High risk of disease transmission
Low risk of handling	Significant risk ofhandling
Contains 80% N, 55% P y 60% K of the sewage effluent	Contains 10% N, 25% P y 30% K of the sewage effluent
Daily disposal per person: 1.5 - 2 L	Daily diposal per person: 0.15 L

Table 2. Maincharacteristics of urine and feaces.

Only few decades ago, human excreta along with urine were used as fertilizers in rural areas. This practice was very common in countries like USA and Europe. As we can see in table 2, feaces contain significant amount of Potasium that often is scarce in the soil. Urine is an effective foliar fertilizer which adds Nitrogen to the plants.

Moreover, feaces is a substance full of pathogens (bacteria, helminths and protozoa) that cause diseases like: diarrhea, typhoid, gastritis. Additionally, urine is a human residue that is harmless; its content in bacteria is really low but on the other side its high concentration of Nitrogen makes it highly pollutant; especially if it is thrown into the environment without previous treatment.

The challenge of a resilient sanitation is based on searching for a safer and easier form of treating human excreta thus regaining its nutrients, and integrating them back harmless into the environment and the productive cycle. In the ecuadorian context has prevailed sanitation with flushed water; but in parallel alternative technologies are being developed in order to minimize the water use/abuse for this purpose, known as dry sanitation.

2.1 SANITATION WITH WATER DISCHARGE

The traditional system needs amounts of clean water between 3 to 23 liters to evacuate small quantities of excreta. According to PAHO [7] it is estimated that toilets use more than 60% of water destined to domestic consume. Without an adequate treatment, it represents an important focus of infection for water streams, lakes and groundwater.

On this issue, Esrey [8] esteems that in developing countries, 90% of sewer water are directly discharged into the environment. For the percentage of people who do not have access to water through pipes, traditional sanitation is not even an option.

There are factors that deepen the sanitation gap among a population. There are taboos around defecation itself. It was found that those who use sanitation practices different to the rest of the people can be discriminated. Also, due to male predominant culture, an appropriate sanitary installation does not represent a priority at home since men do not find bigger obstacles in deposing his wastes anywhere.

Traditional sanitation has other disadvantages. Women in the rural settlements are fear to go to the collective latrine –normally built up out of the house- because they may be raped or attacked for a wild animal. In these circumstances, the most common practice is open defecation.

On top of it, we can add elements like cosmovision of ethnic groups that coexist in the same territory. In some cases, it is believed that the excreta does not represent a risk and can be incorporated in nature immediately, without previous treatment. Also, some religions, have played a role in making invisible the correct management of excreta and the corresponding hygiene.

2.2 SANITATION WITHOUT WATER

Sanitation without water is approached as a new and improved technological alternative, specially if we compare it to versions like traditional latrine (hydraulic sanitation). Its operation allows to build it up near or even inside the house, without health risks when it is used in a suitable manner.

The lack of access to water supply and sanitation in developing countries makes the use of waterless sanitation a priority; this unfilled gap remains an issue in the frame of human rights to water and sanitation, declared by the United Nations.

The Comission for Social Studies of Health [9] registers that almost half of the inhabitants of developing countries lack of access to sanitation. In this framework, we can point out that insufficient investment in sanitation increases the propagation of a of pit latrines that pollute the groundwater and harm public health.

The advantages of sanitation without water, compared to with wáter one, are based on aspects related to environmental degradation, water saving and reusing the nutrients of excreta and urine. In this vision, Wagner and Lanoix [10] indicate that feaces disposal must be separated of urine, because we can obtain an elaborate product from each one of them rich in Nitrogen and useful for activities like agriculture.

Recent studies conducted by Feachem [11] points out as the solution to health´s problems caused by the wrong management of excreta does not only consider techincal aspects but human ones. He prioritizes the prevention of diseases through community participation with a strategy of adapting "viable solutions" to local conditions, financial resources available, political decision of the authorities and –most important- to the culture and habits of the population subject to intervention.

Nevertheless, the introduction to this type of technology requires a deep education process that will allow to raise awareness about the utility of an adequate sanitation. We must work in deepening the understanding of the importance aligning concepts, action and intentions to induce transformations in people´s health, thus igniting the transition from vicious cycles to virtuous cycles.

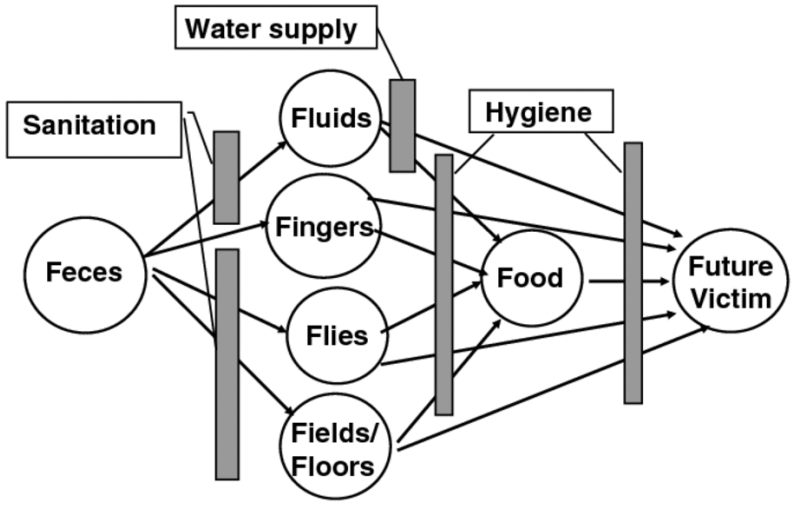

Figure 1. Scheme of barreers of the sanitation without water for the transmission of diseases.
Source: Guerrero T, Fritche T, Martínez Z, Hernández Y(2006)

Among the positive aspects dry sanitation has, we can count the interruption of the fecal-oral transmission of diseases, developped by Wagner and Lanoix [12]. As "Fig 1" indicates, in this concept two types of barriers must be considered: "primary or physical barriers constituted by the insulation cameras and the separating toilets", while the "second ones consider the integration of urine and feaces together with the disposal of dry soil as the primary treatment of excreta with the handwashing sink, which purpose is to avoid the contact of them with flies and roaches".

2.3 EFFECTIVE SANITATION

According to Gitahi [13]_ "for each dollar invested in water and sanitation services, it generates a return of 4.3 dollars in form of reduction of health costs", a return that may increase in developing countries. Moreover, the 2013 annual report of World Health Organization [14] mentions that at least 842,000 people in low and middle income countries die yearly as a consequence of a deficient hygiene and sanitation.

A recent study to calculate the benefits of sanitation investment, Hutton [15] made a conservative calculation of 30 minutes per person per day, which in a family of six people is equal to 21 non-productive hours per week. An improved sanitation would bring each of these families 1,000 additional hours per year, for working, studying, taking care of children, home tasks and to rest. The yearly economic cost of this time is estimated in more than USD 100 thousand million each year.

World Health Organization [16] esteems there are 2,400 million people in the world lacking a private, clean and safe sanitary room, which generates an incalculable social cost. In countries like India it is estimated that the time people look for a toilet or an open place to deposit the excreta or urine has an economic cost of at least USD $10,000 million. This is equivalent to a 0,5% of its GDP.

Then, if the benefits of investing in fulfilling the human right to proper sanitation are so evident and the harm caused by omitting it kills yearly by far more human beings than all terrorist attacks together, there is no reason to desist in the idea of low cost bathrooms.

It is very useful to remember, that the idea of using water to evacuate our excreta was initiated in the times of the Roman Empire, where due to the health crisis caused by open defecation the solution identified was to use rivers as sewer. This indicates that our society has 2,000 years of unawareness polluting clean water that many human beings need.

III. DRY TOILETS FOR MANABÍ

Our lifestyle is normally a sort of mirror of the habitat we live. As most of the territory of the Manabi province is arid, the use of water for toilet discharge is not an option since the same volume of this liquid could be used for other priorities. This is the reason why a new approach for sanitation is needed, one where water is replaced by a dry and abundant material which will not be consider a waste but a resource.

On 2013 the Municipality of Junín (Manabí) in coordination with the "Governance of the water and sanitation sector in Ecuador within the framework of the Millennium Development Goals" a United Nations Development Programme made an effort to expand the coverage of this service in the rural area of this municipality. Dry toilets were designed and conceptualized for the local conditions and build up using a participatory approach among the families.

As follow, dry sanitation was recognized as an appropriate technology to mitigate the high incidence of health problems caused by the inadequate disposal of excreta into water streams, as targeted by investing on this alternative solution. Nevertheless, today there is a lack of information that may give evidence of the appropriate use and acceptance of this pilot project.

3.1 UNVEILING THE DRY TOILET

The dry toilet is an alternative of conventional water discharge toilet. It is an evolution of sanitation, because besides achieving a secure sanitation treatment of excreta, it has important benefits, among the ones we can count:

- Preserve drinking water;
- Can be used as an agriculture substrate, full of nutrients;
- Decrease the cost of building and maintenance of sewer networks;
- Prevents the contamination of water bodies;
- Less vulnerable to extreme natural phenomena such as earthquakes, hurricanes and droughts, among others.

According to permacultural expert Antonio Moretti [17], the dry toilet is one of the most resilient options for arid areas. In his experience in arid northern Chile, water sewer networks are the principal source of pollution of water sources and public areas which cause water based diseases.

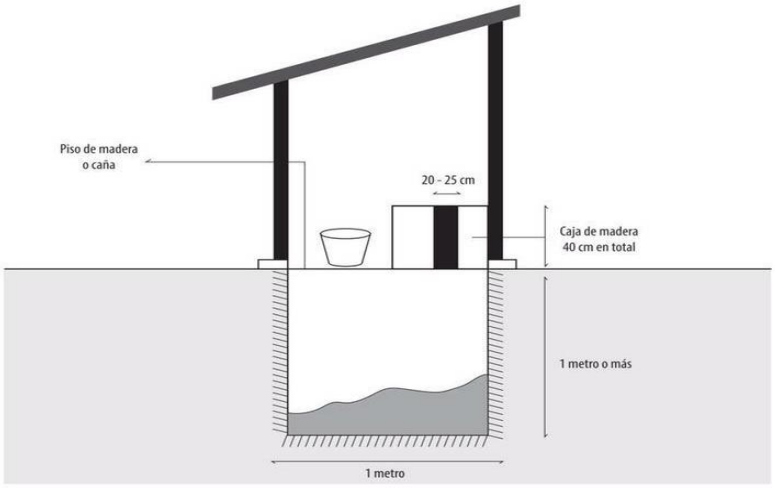

Figure 2. Scheme of a dry toilet.

In that sense, as "Fig. 2" points out dry toilets are especially useful in areas of seismic disaster just like the one Chile suffered on 2010. On those circumstances, water supply networks usually collapse and interrupt the service and may create a serious collateral damage if sewer system is mixed with potable water.

Waste	Treatments	Uses
Urine	Storage	Liquid fertilizer
Feaces	Dry composting, anaerobic digestion	Biogas, soil fertilizer
Grey water	Artificial wetlands, artificial lagoons, biological treatments, gardens	Irrigation, reuse, groundwater recharge
Rainfall	Chemical treatment, biological treatment	Water supply
Organic garbage	Dry composting, anaerobic digestion	Biogas, soil fertilizer

Table 3. Use and treatment of human waste

According to Antonio Nuñez Jimenez Foundation [18] the different ecological sanitation techniques work under the premise of separating the residues at the beginning of the process using inexpensive treatments, simpler, with a better recovery of the existent nutrients and hygienically safe. For this purpose we have to observe the characteristics of each residue, its components and the safest processes of sanitation indicated in "Table 3".

The process of excreta dehydration is performed by separating fluids and solids, heat, ventilation and drying material, all of the ones gradually decrease humidity, thus avoid bad odours and flies. Even though the microbiological information of the final product is scarce, the deactivation of pathogens depends on time, temperature and humidity. McJunkin [19] in his vast experience writes that anaerobic systems may develop temperatures of 50 to 70 degrees, wherefore he suggests the excreta must be stored during a minimum three months to obtain an innocuous product.

IV. CONCLUSION

By the analysis of the data presented in this article, we may conclude that dry toilets represent a useful and sustainable approach on its three dimensions (economical, environmental, and political) to expand the coverage of sanitation. Furthermore, it has the conditions to be implemented in arid and semi arid regions since water supply is not a sine qua non requirement to operate. Since the waste is confined into a drying chamber the risks of contamination are practically null.

Unfortunally, there is little research on this regard by projects where dry toilets have been implemented in Manabí. Go profound on this subject is a must with the likely involvement of academic institutions, public offices, NGO´s, INGO´s and civil society in general may generate a platform to expose successful examples of running projects in rural and urban areas with purposes of housing, tourism and of others.

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