Aspects for the implementation of graywater reuse systems in rural communities in the State of Ceará - case study: São José Project III

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Summary

The water shortage is one of the main characteristics of the semi-arid region, combined with the hot climate, high rates of evapotranspiration and irregularity of rainfall in time and space that contribute to the reduction of water availability, resulting in a worrying picture. The drought that affects the whole sertão of the Northeast, especially the region of Ceará, strengthens the need to review some paradigms related to water use. One of them concerns its reuse, thus promoting a second use for water, releasing superior quality water for noble uses and generating savings and, at the same time, reducing the environmental impact. By reusing grey water, which used to be wasted and used for agricultural purposes, generating water savings and bringing food with nutritional value to the menu of families in the rural area. The Secretary of Agrarian Development, through the São José Project, has implemented in the state of Ceará 15 systems for the reuse of gray water for agricultural purposes, in the search for water alternatives, such as the reuse of gray water, helping rural people to live with drought and strengthening the sustainable rural development in the state of Ceará. The study aims to address briefly the whole process that involved the implementation of graywater reuse systems, from sensitization and training in communities and families served by the Project to its implementation, agro-ecological management and monitoring.

Keywords: Reuse system. Graywater. Agro-ecological management.

Aspecto da implementação de sistemas de reutilização de águas cinzentas em comunidades rurais no Estado do Ceará - estudo de caso: Projecto São José III

Resumo

A escassez de água é uma das principais características da região semi-árida, combinada com o clima tropical, altas taxas de evapotranspiração e irregularidade na frequência e distribuição da precipitação no território, contribuem para a redução da disponibilidade de água e resultam num quadro perturbador. A seca que afecta todo o Nordeste, especialmente o estado do Ceará, reforça a necessidade de reavaliar os paradigmas relacionados com o uso da água. Um deles refere-se à sua reutilização, o que permite libertar a água de qualidade superior para usos mais nobres, promovendo a economia, bem como a redução

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do impacto ambiental. Assim, as águas cinzentas que anteriormente eram desperdiçadas são utilizadas para fins agrícolas, gerando economia de água e trazendo alimentos com maior valor nutricional para o menu das famílias da zona rural. A Secretaria de Desenvolvimento Agrário, através do Projecto São José, implementou no Estado do Ceará 15 Sistemas de Reutilização de Água Cinza para fins agrícolas, com o objectivo de trazer alternativas à escassez de água que prejudicam as culturas, ajudando o homem rural a coexistir com a seca e reforçando o desenvolvimento rural sustentável no Estado do Ceará. Este estudo visa resumir todo o processo que envolve a implementação destes sistemas, desde a sensibilização e formação nas comunidades e famílias beneficiárias, à sua implementação, gestão agroecológica e monitorização.
Palavrvas-chave: Sistemas de reutilização. Água cinzenta. Manejo Agroecológico.

1 Introduction

The waste of graywater is something common in all communities. It is observed in the backyards in the interior of the state of Ceará these waters being thrown into the open air, even in homes that have some kind of effluent treatment such as septic tanks. Thus, untreated effluents contaminate the soil and the water, besides causing diseases to the animals that ingest it.

According to Hespanhol (2003), water has become a limiting factor for urban, industrial and agricultural development in arid and semi-arid regions. Thus, planners and water resource management entities are continuously seeking new sources of resources to supplement the small amount of water still available.

Among the wastewater generated by the different activities of society, graywater is cited. For Kibert and Kone (1992 apud BORGES, 2003, p. 27), graywater is defined as all the sewage generated in a house, except that coming from the toilet bowl. After its treatment, graywater can be used as a source of water for non-potable use such as irrigation, toilet flushing, construction, among others, being a very common practice in several countries such as the United States, Germany and Japan.

According to Eriksson (2002 apud MAY, 2009, p. 72), the use of the graywater reuse system has some advantages, among them: it stimulates the rational use and conservation of drinking water; it allows the maximization of the water supply and sewage treatment infrastructure by the multiple use of the water adducted and favors environmental education.

The São José III Project, in its component of Water Supply and Sanitary Sewage Supervision - SAAES, works with the implementation of Supply Systems - SAA and Sanitary Modules - MS, composed of a bathroom with shower, sink, toilet, water tank, and septic tank. Aiming at giving continuity to the projects, bringing quality of life to the population, reducing the environmental impacts and the waste of water, besides bringing food and nutritional security to the benefited families, generating income with the commercialization of the production surplus.

In the selection of families, the Graywater Reuse Project prioritized the communities that already had an OSS and a MS, because it would guarantee the supply of treated water for use and, consequently, the production of graywater, besides the minimum risk of contamination, due to the presence of a septic tank in the residence. Families with an average consumption of 8m³ per month were selected, guaranteeing the input of gray water in the system, as well as these should have the aptitude for family farming, committing to continue with a good management of the system and having the time to participate in all the trainings offered by the PSJ III, especially on how to implement the physical part and manage the system, preventing it from being mismanaged in the future.

The communities benefited by PSJ III are located in the semi-arid region of Ceará, therefore subject to water scarcity. The insertion of technologies such as these brings the possibility of reducing local environmental impacts, such as soil salinization, guaranteeing the production of water, enabling the use of noble waters by the family and the reuse of grey waters for production, which would otherwise be wasted, in addition to ensuring healthy and pesticide-free food for the needy population and farmers of the semi-arid region, and can also generate income for families with the sale of surplus production. Initially, fifteen reuse systems based on the Family Bio-water technology were implemented in the communities of Cristais in Cascavel-CE, Umarizeiras in Itatira-CE, and Aba da Serra

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in Piquet Carneiro-CE, five systems in each location. The objective of this work is to present the whole methodology process for the implementation of the graywater reuse system that benefited families in rural areas of Ceará State..

2 Methodology

The gray water reuse project was carried out in several stages, such as: elaboration of criteria to be required for the selection of the families; sensitization in the communities; diagnosis of the areas to be implanted in the system; exchanges; training for the technicians and families; hydraulic sizing in the reuse family units; elaboration of the project for each community, signing a later agreement with the Association benefited; implantation of the system; follow-up of the families benefited and monitoring of the implanted systems. The implementation methodology was based on and adapted from the one developed by the Dom Helder Câmara Project, in the Family Bio-water systems, in which the technicians of the Agrarian Development Secretary, as well as the families, were trained to implement all the stages of the reuse system.

The water reuse system includes: a 300m² fenced area; a grease box; a biological filter; a reuse tank; an irrigation system; a worm house; a seedling nursery, and vegetable beds.

The definition of the criteria to be required for the benefit of the reuse system project had the participation of the São José Project technical team and the World Bank consultants (Project funding agency), taking into account the target audience and their experience with the projects that were benefited by the Secretariat of Agrarian Development, through the São José Project.

- The criteria established were as follows:
- - Community served with the Water Supply and Sanitary Drainage System - SAAES by the São José Project;
- - The water supply system managed by SISAR;

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- - Family must be composed of at least 4-5 people in the residence and work in the rural area;
- - Agricultural aptitude of the families to be benefited;
- - Vocation for growing vegetables and agro-ecological practices;
- - Interest in participating in the reuse project and availability to participate in the training sessions;
- - Production of water with an average flow of 8 m³ per month;
- - Have a yard for installation of the Project (300m²).

2.1 Awareness-raising moment - presentation of the project

The definition of the criteria made it easier to make a list of the communities benefited by the São José Project with the Water Supply and Sanitary Sewage System, and among them the community of Cristais was one of those visited to present the Project and raise awareness about the efficient use of water and the environmental impact.

The communities of Cristais - Cascavel, Umarizeiras - Itatira, and Aba da Serra - Piquet Carneiro were mobilized for a meeting, in which the Project for the reuse of grey waters was presented, highlighting the criteria that the families to be benefited should meet and the commitments to be signed by them for the good use of the reuse system.

During the sensitization meeting, a list of the candidates to be benefited by the project was built and, in a second moment, the families were visited by the technicians of the São José Project for an evaluation and diagnosis following the criteria defined for the Project, with 5 families per community selected to be benefited.

2.2 Diagnosis of the areas to be implanted

The areas of the families interested in receiving the Project were visited by technicians of the São José Project in order to identify the points of water supply for domestic use. In the field, the families interested in receiving the project were visited, being evaluated the number of people per residence, the average production of water per month,

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the output of gray water and if they had an available area of 300m² for the implementation of the reuse system..

2.3 Exchange Realization

In order to implement the gray water reuse system in the State of Ceará and present the experiences of the families benefited with the reuse system by the Dom Helder Câmara Project in Rio Grande do Norte, the São José III Project carried out the exchange taking the selected families and their technicians to get to know the system and experience the Project proposal.

The event, besides focusing on the presentation of the system and its management, showed the experience of the benefited community with the environmental actions developed, presenting the activities through workshops with the participation of local school students. During the exchange in the community Olho dos Borges in Caraúbas-RN 4 families benefited from the reuse system were visited, showing their experience with the project and answering questions from farmers and technicians.

The environmental education developed in the benefited community was presented from the involvement of children, teenagers and teachers in a rural school near the Settlement Project - Nova Morada - Caraúbas (RN) - where the water reuse systems were implemented, in order to provide a reflection of integrated actions to better understand the need for conservation of soil, water, flora, fauna and, above all, the proper disposal of solid waste on farms in the semi-arid region. From this referential, it was shown how the environmental education activities take place in line with the rural schools linked to the communities and settlements that implant the reuse systems.

The exchange provided the generation of information about the management of reuse systems and environmental education events held in two moments, the first happened in Caraúbas/RN in 2014. Before the implementation of the reuse system in Ceará by the São José Project, another exchange took place in 2015 in the municipality of Iguatu/CE, after the implementation of the Pilot Project.

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2.4 Training for system implementation

The families benefited with the Gray Water Reuse Systems, besides acquiring a technological innovation in the field, also needed to know the agro-ecological management practices to be performed in the production areas of the reuse system, because most of the beneficiary families who met the Project criteria had as field practice only conventional agriculture, using pesticides and other conservationist practices. In view of this reality, all the families participated in various stages of training in the management of the reuse system and in agricultural management, as well as in exchanges to get to know the reuse system of gray water in operation, and also participated in the implementation of the system within the learning-by-doing methodology in which, initially, all the beneficiaries participated in the implementation of the first system in each community, and then implemented their own reuse system..

2.5 Training the beneficiaries to implement and conduct the graywater reuse system in Ceará within the learning-by-doing methodology

The families, after knowing and experiencing the experiences of the system implemented by the Dom Helder Project in Rio Grande do Norte, participated in the first implementation of the graywater reuse system in the state of Ceará, in the municipality of Iguatu, carried out by the São José Project.

In the implementation of the reuse system pilot project held in the Diocesan Training Center of Iguatu-CE, the methodology of learning by doing was applied, thus all the benefited families and technicians of the São José Project built the reuse system, appropriating the learning acquired during the assembly of the project in the field.

During the event, the beneficiary families and technicians went through theoretical, methodological, and practical training, addressing the operation of each component of the reuse, and agro-ecological management, following the schedule below:

Field practices on the monitoring of the reuse system of the Training Center:

- Maintenance and management of the fat box;
- Management of the biological filter;
- Management of the earthworms;

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- Production of organic compost (closing the cycle of the biological filter residue);
- Irrigation and recording of water production in the SBF;
- Protection against pests and diseases from (agro) biodiversity in and around the SBF;
- Intercropping
- Functional living fences;
- Crop rotations;
- Attractive plants and repellents;
- Soil management;
- Management of seedlings in the mini-till (planting and replanting);
- Hygienic measures in the management of reuse water;
- Monitoring of reuse water and food under Brazilian legislation;
- Hygienic-sanitary procedures for harvest and post-harvest;

Theoretical and methodological approach on the graywater reuse system, the following subjects were punctuated:

- Agroecological perspective applied to the System;
- Ecosystem and agroecosystems;
- Energy flow;
- Recycling of nutrients;
- Food chain and web;
- And some existing relationships in agroecosystems and ecosystems.

For the dynamics used in the implementation of the system, each team was responsible for the execution of a subcomponent of the reuse system, and the members rotated with the other members of other subcomponents of the reuse system.

Initially, the hydraulic sizing was done, followed by the staking of the 300m² area where the system was implemented. At the end of the meeting, an evaluation of the training was conducted with the beneficiary families and the technicians, and they were invited to return after 90 days for training in the management of the system implemented in November 2014.

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2.6 Training in agro-ecological management of the graywater reuse system

Ninety (90) days after the implementation of the reuse system in Iguatu-CE, and exactly at the moment foreseen for the training in monitoring, a first stage of the training cycle is closed, in which the participants were able to learn, through practice and theoretical reflection, the logic, principles and procedures for monitoring the various sub-components that make up the reuse system.

The methodological process of monitoring the reuse system - School of Iguatu/CE - was based on the "route of knowledge" with farmers and technicians about the functioning aspects and means of correction in relation to the subcomponents of the reuse system. The proposal was to generate knowledge through the interaction of all the participants in the technical aspects and putting people to think about how in fact it is possible to manage the various subcomponents. In this way, the operation of the system was monitored, covering:

- Management of vegetables, medicinal plants, fruits and forage crops, mulching, carrot thinning, pruning of fruit trees and moringa, planting of beets, cabbage, peppers etc.

- Record of grey water production, showing the average daily production;

- Recording the production of food, recorded by noting the weight and/or unit of the food harvested;

- The level of crop diversification, aiming to verify agrobiodiversity;

The "learning route" methodology has been used by the São José III Project technical team to follow up the 15 reuse systems implemented in the families of the three communities. In addition, the technician's time is optimized in relation to the other demands of his responsibility.

3 Analysis of the results

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3.1 Water source

The graywater produced in the rural residence is converged to the biological filter by gravity and to the reuse tank. From this tank, the treated water should be pressurized by the electric pump drip irrigation system. The main sources of gray water in rural households are sinks, washbasins, and showers. It is worth noting that graywater excludes toilet water. The source of water for domestic use of the residence is originated, mainly, from springs, that through the Supply System implanted by the São José Project in the community, treats the water served to the residence, other effluent used comes from 16.000l and 52.000l cisterns located in the residences.

It is estimated that in a residence, on average living with 4 to 5 people, has a graywater production of less than 500l/day and had as reference the water bill paid by the farming family in the last 3 (three) months. Therefore, it is recommended the implantation of 1 Biological Filter (BF). For this, the monitoring of this water was observed daily from values noted on hydrometer, which proved the monthly average of water production.

3.2 Hydraulic dimensioning, irrigated area and management

It was conceived aiming to form hydraulically independent sectors. Such independence will be given by means of 16 mm polyethylene valves coupled at the beginning of the polyethylene lines (16 mm). Four (4) sectors were formed, being: 1 (one) for the production of leafy and tuberous vegetables in 2 (two) beds; 1 (one) involving the irrigation of fruit type vegetables; 1 (one) in the production of fruit trees; and 1 for the irrigation of live barley trees (Gliricídia and Moringa). Emphasizing that the latter will serve, above all, to discharge the excess of gray water produced during the rainy season and when the residence has a larger than normal number of people. It is estimated that the water need of the productive backyard is 457 liters, being: 122 liters (sector 1; 2 beds); 17 liters (sector 2); 185 liters (sector 3); 133 liters (sector 4).

The critical design flow rate for sizing the dripline was based on 1.06 m3/h, i.e. critical flow rate of 1 (one) dripper sector on 2 beds. The total irrigated area is 246 m2.

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The diameter of the pipes was sized according to the Bresser formula, while for the pressure drop the Hazen Williams formula was used. A water velocity limit of 2.5 m/s was used for the polyethylene pipes. The total manometric height was equal to the sum of the following parts: lateral head loss (m.c.a.); head loss in the derivation (m.c.a.); head loss in the elevation (m.c.a.); service pressure (m.c.a.); head loss in the filter (m.c.a.); head loss in the accessory parts (m.c.a.); terrain unevenness; safety margin of 5%.

It is recommended that irrigation be carried out simultaneously according to the table below:

QUADRO 01 – Recommendation for the operation of the Reuse System Irrigation System.

Irrigation Sectors	Irrigation Branches Flow	Flow (m^3/h)	Time (h)
1	Gotejamento	1,06	0,11
2	Gotejamento	0,18	0,09
3	Gotejamento	0,35	0,48
Irrigation time vegetables and fruits			0,68
4 (Living Fence: Gliricídia and Moringa)	Drip	0,88	0,14
Total			**0,82**

Fonte: Manual de implantação de bioágua, 2015.

According to the table above, it is possible to observe that the daily working day devoted to the production of vegetables and fruits is 0.68 h, or 41 minutes. Whereas, the time for the water supply of the living fence (Glyricidia and Moringa) is 0.14 hours, or 8 minutes. It is recommended that irrigation for living fences be performed at least twice a week.

It is important to adjust the irrigation management with the on-site meteorological data, which should also include a leaching blade to maintain the hydrosaline balance of the soil.

Estimated consumption of electrical energy in drip systems with graywater culture, by the use of a pump in pressurized system:

QUADRO 02 – Estimated power consumption in the Reuse System.

ESTIMATED ELECTRICITY CONSUMPTION	
Daily operation time (h)	0,82
KW consumption (hour) of the electric pump	0,30
Consumption of KW (day)	0,24

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Consumption of KW (month)	7,00
Average value of KW (hour)	R$ 0,34
Average monthly value	R$ 2,49

Fonte: Manual de implantação e manejo do sistema bioágua familiar, 2015.

The following is a sketch of the area without scale:

Figura 01 – Visão geral do sistema de reúso de águas cinza implantado pelo Projeto São José/SDA e os seus componentes (1 – Filtro Biológico; 2 – Tanque de reúso; 3 – Eletrobomba; 4 – Compostagem; 5 - Minitelado; 6 – Minhocário; 7 – Canteiros de hortaliças; 8 – Linhas de Hortaliças tipo fruto; e, 9 – Linhas de frutíferas).

3.3 Hydraulic convergence

Graywater from rural residences in a reuse system should be converged by gravity with gravity sewage piping, passing through a fat box that has the purpose of promoting the decantation of oils with a longer structural chain that can compromise the development of the earthworms, up to the Biological Filter. It is recommended that the sewage piping be at least DN 50. Therefore, the technical considerations pertinent to the recommended diameter for the referred piping to the Biological Filter follow.

The pipes that directly receive the wastewater from the sanitary appliances are called discharge branches. These are the pipes that connect the sanitary appliance to a backflow preventer (for example, siphoned box or known as drain, fat box, siphon). According to the Brazilian Standard (NBR) 8160/1999 (ABNT, 1999), the minimum piping

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is 40. The piping that receives the effluents from the flushing branches directly or from a backflow preventer is called sewer branch. Gray waters are converged to a fat box (essential to precipitate substances of higher molecular weight). The hydraulic convergence system should be deployed by gravity to the biological filter.

3.4 Biological filter

Downflow unit with a surface area of 1.77 m², with two layers of organic material (humus5 and wood sawdust) and two layers of inorganic material (gravel and pebbles), distributed in a depth of 1.00 m. For the design of the system, it is important to note that a filter has the capacity to treat up to 500 liters of gray water per day, which should be distributed evenly, in order to provide for the multiplication and development of the earthworms on the surface of the filter. One should regulate the amount of gray water daily with a 32 mm stopper attached to the beginning of the 'shower' and avoid clogging the water distribution holes in the filter. Thus, this reference serves to design systems with different water offers. For example, a household that offers a volume above 500 liters of gray water per day should have 2 filters. The filter should be covered to avoid direct sun and rain. In addition, the top of the filter should be covered with a 50% Sombrite screen to make the environment darker and reduce problems with some earthworm predators.

It is essential that these materials (humus and wood chips) do not become waste material when they return to the environment in the form of a potential contaminant. To avoid this problem, this residue resulting from the maintenance of the biological filter and the fat boxes is recycled by making organic compost, together with cultural remains, grass, and manure, generating a stabilized organic fertilizer with great fertilizing power for all implanted cultures. This practice of composting allows the system the status of a system without any environmental waste or Zero Waste.

3.5 Reuse tank

Its function is to store the reuse water coming from the filter, with a capacity of 1,767 liters. It must have a closed upper part to avoid the incidence of sunlight and allow

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the proliferation of algae, which alter the quality of the water and compromise the pumping system. It also avoids possible accidents and the proliferation of dengue mosquito larvae, among others. The reuse tank is attached to the irrigation system.

The Biological Filter is a concrete tank, 1.5 meters in diameter and 1.0 meter deep. From bottom to top it is composed of: pebbles (20 cm); gravel (10 cm); washed sand (10 cm); wood shavings (50 cm); and worm humus (10 cm). The treatment in the filter is carried out, firstly, by the ingestion of solid and organic substances that come from the gray water. The worms feed on this material and excrete it in the form of nutrients, essential for the growth and development of plants, such as calcium, phosphorus, magnesium, and sulfur, as well as humic substances that are transformed into nitrate. It is essential that the dishwashing sink is one of the sources of gray water, because the worms' food comes from the solid residues suspended in the gray water. In addition, it is necessary to protect the surface of the biological filter with a black screen (sombrite), because the worms are strongly sought after by lizards, ants, and frogs. Also, earthworms do not have a habit of developing in a space with exposed light. The earthworm that should be part of the filter is the California Giant, which is red in color. This species specializes in the decomposition of solid waste and is resistant to moisture in its habitat. However, it does not tolerate flooding situations. The African Giant should not be used for this type of use, as it does not thrive in wet environments and can easily lead to mortality.

The second filtering medium is the wood shavings that retain substances and create an environment that is still decomposing. On average, after 6 (six) months of operation of the filter it is normal that there is a lowering of the two upper layers, humus and wood shavings. Therefore, it is necessary the due replacement of the mentioned materials so that the BF can present efficiency.

3.6 Irrigation system

Irrigation management in reuse systems should be constant, adjusted according to the supply of treated graywater. The area of each yard is based on the experience

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developed by the Dom Helder Câmara Project, which is 300 m² (20m x 15m). For a rural residence in the semi-arid reality of Ceará, it is estimated, on average, that the production of grey water is less than 500 l/day. Thus, the implementation of a BF is recommended. It is also recommended the formation of hydraulically independent sectors.

The critical design flow rate for sizing the derivation line is 1,06 m³/h, in other words, the critical flow rate of 1 (one) drip sector in 2 beds. The total irrigated area is 246 m².

3.7 Minhocário

The California giant earthworm specializes in purifying the environment, and is also considered to be an indicator of environmental balance. It is used in the reuse system as part of the graywater treatment for the purpose of reuse in irrigation in productive backyards. The other part is the physical treatment, through the layers of saw dust, sand, gravel and pebbles that act as filtering elements in the biological filter.

The worms that are part of the Biological Filter are heavily preyed upon by ants, frogs, lizards, and birds, as they are protein-rich worms that are much sought after in the food chain. A high level of ant infestation has been observed preying on the earthworms in the BF. This is extremely harmful, as they are easy prey and their death decreases the efficiency of the FB treatment. To this end, it is recommended to make a 'round pool' around the biological filter, in order to prevent the entry of ants. In addition, a black tarpaulin should be placed over the biological filter to contain the attack of lizards, and coconut pales should also be placed to protect the soil, since earthworms are sensitive to sunlight.

The earthworm culture is strategic for maintaining the production of humus in the reuse system, used when changing the humus layer of the FB and as a substrate in the production of vegetable seedlings in mini-tanks.

The management of the worm farm should be directed towards staggered production and care of the worm predators. The manure should be tanned and the slurry removed before entering the concrete ring of the worm house. Place tanned manure up to

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half of the ring. After approximately 60 (sixty) days, the other part of the ring is filled alternatively, and so on. The top part of the ring should be sifted first, because the worms compost from the top down, probably due to the oxygen conditions.

The care of predators should be in a systematic way and meet the recommendations listed in the previous item. It was observed in the minhocarium of the System in Iguatu-CE the high mortality of earthworms, due to a massive action of predators. Therefore, the same recommendations for FB apply for the worm farm.

3.8 Composting

Composting plays a fundamental role in SBF. It contributes to the production of organic fertilizer, from the composting of organic waste such as vegetable peelings, grass, manure, among others. The management of the composting should be directed towards the formation of at least three (3) layers at different times. The layers should be formed from the organic material peels produced in the restaurant, associated with others to form the composting operation pile. Humidity is fundamental for the maintenance of the decomposition rate, being the most favorable when there is no runoff from the pile. It is recommended that every 20 days the layers be turned over.

Between 80 and 90 days the composted material is in condition to be used as organic fertilizer for the various crops.

3.9 Technical follow-up

The graywater reuse system after the filtering process (physical and biological) provides water to be used in an irrigation system intended for the production of vegetables, roots, fruits, medicinal plants and other types of food. When treated gray water is used to irrigate edible crops, the highest risk situation is for crops consumed raw. The São José III Project, thinking of guaranteeing to the benefited families the necessary qualification in the maintenance and management of the reuse system, made available a technician to perform a weekly technical follow-up that could contribute to the adaptation of the family. Initially, as shown in the following chart, the technical follow-up started right after the

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conclusion of the system with 4 monthly visits, reaching up to 5 visits. Remembering that these visits are technical ones directly aimed at the accompaniment from the technical orientations.

Technical assistance is a preponderant factor in the search for successful results, especially when thinking about agroecology transition. Positive and negative points were observed during the realization of the technical visits:

Positives:

- Availability and commitment of the family to the system;

- Realization of management practices, pruning, natural defensives, composting, among others;

- Participation in a free fair with the products produced in the reuse system;

- Participation in events and exchanges;

- Exchange of experiences with other entities.

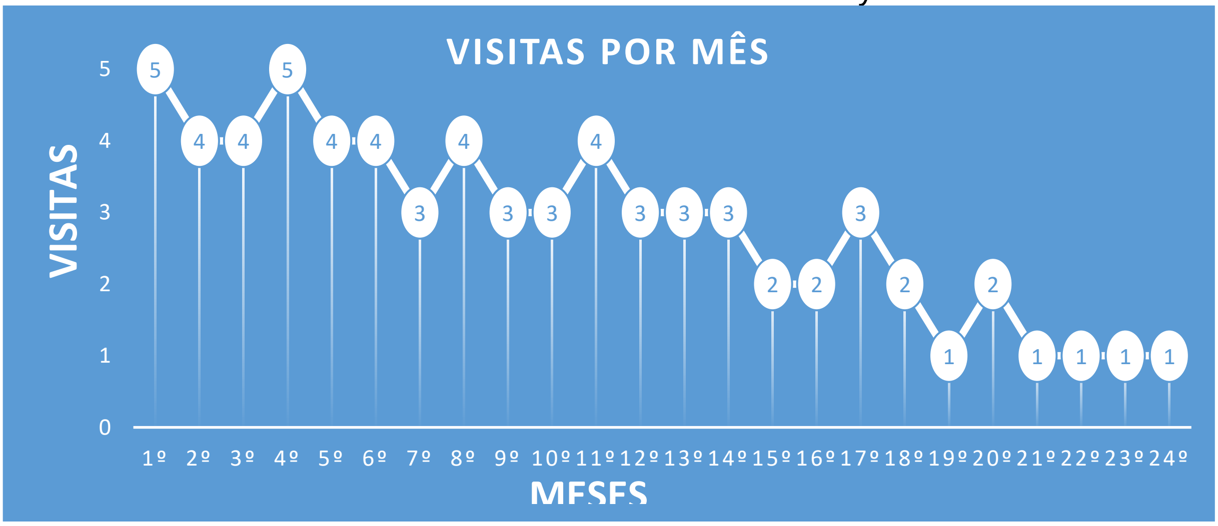
Negatives:

- The lack of water in the community's supply system;

- Excessive use of chemicals in the home.

The following chart shows an average of technical visits in the community of crystals, in Cascavel:

GRAPH 01 – Technical visits made to the Cristais community in Cascavel



Fonte: Dados das visitas técnicas realizadas em Cascavel até o ano de 2017. Projeto São José III, 2018.

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3.10 Production data

The graywater reuse system provides the benefited families with access to the production of vegetables, fruits, roots and tubers in the irrigated backyard from the supply of post-treated water supplying the family demand and the surplus being possible to sell.

The following table shows an example of production in one of the communities where the system was implemented:

QUADRO 03 - Agricultural production of a Family Unit reuse system in the town of Cristais, in Cascavel.

PRODUTO	PRODUÇÃO			Unidade de produção	DESTINO DO PRODUTO			Unidade de produção	VALOR DA VENDA – R$	
	Molho	PÉS	KG		Consumo	Venda	Doação		Vr. Unit.	Vr. Total
Alface		155		**155**	83	55	17	**155**	1,5	**82,5**
Beterraba			15	**15**	10		5	**15**	1	**0**
Coentro/ Cebolinha	194			**194**	92	70	32	**194**	1	**70**
Cenoura			7	**7**	7			**7**	1	**0**
Pimentão			42	**42**	22	11	9	**42**	1	**11**
Tomate			41	**41**	27	9	5	**41**	2	**18**
Repolho		20		**20**	19		1	**20**		**0**
Pepino			12	**12**				**0**		
TOTAL	**194**	**175**	**117**	**486**	**260**	**145**	**69**	**474**	**7,5**	**181,5**

Fonte: Dados das autoras, 2017.

Given the previous table, it is clear that this family unit can produce on a good scale, even knowing the limitations imposed by the system, given the low production of gray water after treatment. Even so, the family was able to participate in free trade fairs, as well as reselling to sellers in the region, however, the main focus is to ensure the family consumption with healthy food.

4 **Final considerations**

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The "learning by doing" methodology was able to unite the knowledge between technicians and farmers regarding the implementation of graywater reuse systems in the communities of Cristais - Cascavel-CE and Aba da Serra - Piquet Carneiro-CE, and in the Umarizeiras Settlement - Itatira-CE.

The monitoring of the management of the reuse systems is fundamental, so that they work with techniques that allow the maintenance and/or elevation of soil fertility, the non-use of any type of man-made chemical product, plant diversity, continuous production of worm humus and organic compost, natural alternative control of pests and diseases, among others.

References

BORGES, L. Z. **Caracterização da água cinza para promoção da sustentabilidade dos recursos hídricos.** 2003. 103f. Dissertação (Mestrado em Engenharia). Universidade Federal do Paraná. Curitiba, 2003.

ERIKSSON, E.; AUFFARTH, K.; HENZE, M.; LEDIN, A. Characteristics of grey wastewater. **Urban Water.** v.4, 2002.

HESPANHOL, I. Potencial de reuso de água no Brasil: agricultura, indústria, município e recarga de aquíferos. In: MANCUSO, P. C. S.; DOS SANTOS, H. F. (Orgs). **Reúso de água.** Barueri: Manole, 2003a. cap.3.

PROJETO SÃO JOSÉ III. **Relatório de acompanhamento técnico dos sistemas de reúso.** Fortaleza-CE. 2018.

SANTIAGO, F. *et al.* **Manual de implantação e manejo do sistema bioágua familiar:** reúso de água cinza doméstica para a produção de alimentos na agricultura familiar do semiárido brasileiro. Caraúbas-RN: ATOS. 1ª. ed. 2015.

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