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# Agricultural potential of reject brine from water desalination

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**The purpose of this research was to study the feasibility of growing organic vegetables using the reject brine from the water treatment station in the community of Bom Jesus, in Campo Grande, RN. The research began with the establishment of a community garden according to systematic principles of agricultural sustainability in ecological basis. The participatory planning, in which all activities in the project were planned and performed democratically with the community, was the methodology adopted. Vegetables like coriander, chive, tomato and rocket were grown in the site available for the research, sowing a mixture of legumes with grasses to produce plant material, breeding of elephant grass and planting forest and halophyte species (*Atriplex nummularia*). The appropriate disposal of the reject brine gave a conservative nature to the project and also the possibility of an alternative source of water for agriculture, emphasizing the efficiency of use of water in semiarid regions. It is concluded that there were yield losses in all species grown with water of saline waste, from 25.30 to 26.7%, in relation to the conventional irrigation systems (fresh water); but there was biomass. However, the vegetable growth was successful in the community because it could change the resident's mind about the disposal and reuse of the saline waste.**

**Key words:** Action research, saline waste, water resources, green manure, Brazil.

## INTRODUCTION

The families in the community of Bom Jesus have historically fought and resisted against natural climatic

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factors. The limited and poor water resources is a problem faced by the community, where there are only four small reservoirs to provide water for domestic use and for the animals until a certain period of years, and the residents suffer from water shortage during the dry months. To solve this problem, the Brazilian government conducted the program “Água Boa” according to which a water treatment station by reverse osmosis was installed in the community as alternative for the families to have drinking water (Mohamed et al., 2005; Dias et al., 2011).

Historically, due to its high cost, desalination was limited to applications as a source for potable water and for high-quality water for industrial uses. However, technological advances in the last years have driven down the cost of desalinated water due to reductions in the price of equipment, reduction in energy demand and know-how on water treatment (Tsiourtis, 2001; Fritzmann et al., 2007). In Rio Grande do Norte State, the first desalination plant experience began in 1997 and since then, the numbers of desalination plants have been increasing annually.

The community has been working to build a pipe for water supply in order to solve the problem of water shortage. Meanwhile, the desalination and the tanks are the alternative to ensure domestic water supply. However, the residues (concentrate and brine) resulting from the water desalination do not pass by any treatment or appropriate disposal. They are disposed directly on soil and into the water, causing problems of salinity in soil and affecting water quality in dams and rivers next to the community (Tchouaffe, 2007). It is important to know how salt contamination affects crops. Water is taken up by the fine roots of the crops though osmosis, which involves the movement of water from the area of low salt concentration (such as the soil) to area of high salt concentration (such as inside root cells). When salt concentrations are high, the movement of water from the soil to the root is slowed down. When the salt concentrations in the soil are higher than inside the root cells, the soil will draw water from the root, and the root and the crop will wilt and sometimes die. This is the basic way in which salinization affects crop production.

Generally brine does not receive any treatment in Brazil. However, when poured on soil, it provides high accumulation of salts in soils (Porto et al., 2001) causing short term salinization problems in communities that benefit from the desalination technology. The families concerned about the environmental problems caused by the disposal of saline waste resulting from the water treatment tried some alternatives, but all with very high costs. The Federal University of Semiarid and the technical assistance of the NucleoSertao Verde, in partnership with Program of Undergraduate Research and Technology for Micro and Small Enterprises (Programa de IniciaçãoCientífica e Tecnológicapara Micro e PequenasEmpresas – BITEC 2009), presented a proposal for a better destiny of wastewater from desalination.

Thus, the aim of this research was to study the feasibility of using the reject brine from the water treatment to support the production of organic vegetables in the community Bom Jesus, Campo Grande, RN. The research began with the establishment of a community garden according to systematic principles of agricultural sustainability in ecological basis.

## MATERIALS AND METHODS

This study was conducted from July to December, 2009 with the establishment of a community garden according to systematic principles of agricultural sustainability in ecological basis. The participatory planning, in which all activities in the project were planned and performed democratically with the community, was the methodology adopted. The group already had the basics of vegetable production, but needed specific training. As it was an innovative project, technicians from UFERSA and NUCLEO SERTAO VERDE guided them. Based on the site analysis, an area measuring 12 × 20 m next to the desalination (Figure 1A and B) was chosen, where it was necessary to build a barbed wire fence in order to isolate this area which is central to the community, a nursery for planting seedlings in beds and a small irrigation system using waste water from water desalination processes to support the desalination of crops.

Firstly, there was the site preparation for planting, and the construction of ‘smart beds’ with alternative system for water distribution on subsurface (Figure 2A) in order to avoid the contact of leafy vegetables with the saline waste. The beds were filled with a great amount of plant material (coconut fiber, plant debris, wood remains etc.), once the principle of reduction of matrix soil potential was tried to decrease the deleterious effects of saline waste water on plants. Besides, a legume and grass seed mixture was used in half of the available site (Table 1) for the production of biomass which later served as green manure and organic material in soil.

Vegetables like lettuce, chive, coriander, rocket, pepper and tomato were grown in the ‘smart beds’. Some fruit trees like guava and Barbados cherry were also planted in the area, and some halophyte species like salt grass (*Atriplex nummularia*) and seedlings for reforestation. Aiming the animal husbandry, and considering the higher water demand and the high tolerance of grasses to salinity, a breeding for planting elephant grass was built (Figure 2B) and irrigated with a furrow irrigation system to avoid the saline waste to be adduced into the river.

The surplus production was marketed in the community and in the market-place for family farming in neighbor communities. The resources from the sale of surplus production were used to pay for the production costs. In order to prove the technical and environmental feasibility of using the reject brine, soil and water analysis and characterization were performed in the area according to the methodology proposed by Solos (1997). Besides, vegetable yield (vegetables, legumes and grasses mixture, and breeding) was quantified and the results compared to data in the literature on conventional grows (fresh water) (Maas, 1984; Arruda et al., 2011; Andrade et al., 2012). Samples of treated water were collected by desalination and from the reject brine of the desalination community plant.

The physic-chemical analyses of samples were carried out at Laboratory of Nutrition and Fertility of plants, Environmental Sciences and Technology Department of UFERSA by following the methodology proposed by Tedesco et al. (1995).

(A) (B)

**Figure 1.** Salt water treatment station (A) and disposal of reject brine in soil and water course (B).

(A) (B)

**Figure 2.** Smart beds to grow vegetables irrigated by subsurface (A) and elephant grass grown with furrow irrigation with waste from water desalination (B).

**Table 1.** Composition and quantities of seeds species used in the mixture incorporated into soil material.

| Legume/grass | Quantity (kg $ha^{-1}$) |
|---|---|
| *Zea mays* (L.) | 24 |
| *Canavalia ensiformes* (L.) | 16 |
| *Helianthus annus* (L.) | 8 |
| *Ricinus communis* (L.) | 5 |
| *Calopogonium mucunoides* (L.) | 4 |
| *Pennisetum glaucum* (L.) | 2 |
| *Crotalaria juncea* (L.) | 10 |
| *Crotalaria spectabilis* (L.) | 10 |
| *Mucuna pruriens* (L.) | 16 |
| *Cajanus cajan* (L.) | 16 |
| *Lablab purpureus* (L.) | 12 |
| *Sorghum bicolor* (L.) | 3 |
| *Phaseolos vulgaris* (L.) | 12 |

Samples were classified in accordance with the risk of salinity, sodicity and specific ion toxicity by using the Food and Agricultural Organization (FAO) Guidelines for interpretations of water quality for irrigation (AYERS WESTCOT, 1999).

## RESULTS AND DISCUSSION

The project enabled significant impacts on socio-economic, technical, scientific and environmental aspects in the communities supported by capture and treatment units for water desalination. A discussion was suggested with the families involved in the research, and they found other alternatives for the reuse of saline waste, such as raising tilapia, building evaporation pan to produce minerals, and growing sunflower for oil production and ornamentation (planted in jars). During the experiment, it was found that sunflowers had higher tolerance to salinity from the water of saline waste in relation to the other

**Table 2.** Mean yield of main species grown with saline waste and quality of elephantgrass (*Pennisetumpurpureum* L.) forage in relation to crops grown with water of good quality (conventional system).

| Species | Saline waste | Fresh water | Relative loss (%) |
|---|---|---|---|
| Lettuce (fresh biomass) | 72 g per plant$^{-1}$ | 98 g plant$^{-1}$ | 26.53 |
| Tomato (number of fruits) | 27 fruits per plant$^{-1}$ | 36 fruits per plant$^{-1}$ | 25.00 |
| Pepper (fruit weight) | 43.1 g per fruit$^{-1}$ | 57.7 g per fruit$^{-1}$ | 25.30 |
| Sunflower (dry biomass) | 7.8 ton per ha$^{-1}$ | 6.39 ton per ha$^{-1}$ | 18.00 |
| | | | |
| ***Pennisetum purpureum*** | | | |
| Percentage of dry matter | 80.5% | 90.5% | 11.04 |
| Level of crude protein | 9.5% | 4% | - |
| Salt grass | 8.31 ton per ha$^{-1}$ | - | - |
| Sabiá | 10.4 g per plant$^{-1}$ | 4.9 g per plant$^{-1}$ | 52,74 |
| Jurema preta | 6.76 g per plant$^{-1}$ | 4.3 g per plant$^{-1}$ | 35,93 |

**Table 3.** Treated water and reject brine chemical composition from desalination plant.

| Water | $EC_w$ (dS m$^{-1}$) | pH | $Ca^{+2}$ | $Mg^{+2}$ | $Na^{+}$ | $Cl^{-}$ | $CO_3^{-}$ | $HCO_3^{-}$ | SAR* (mmol L$^{-1}$)$^{0,5}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | ...........mmol$_c$ L$^{-1}$............. | | | | | | |
| Treated | 0.46 | 8.0 | 0.6 | 0.1 | 5.1 | 1.8 | 0.5 | 3.8 | 8.62 |
| Rejectbrine | 5.96 | 7.4 | 22.4 | 8.6 | 39.6 | 64.6 | 0.3 | 8.1 | 10.06 |

*The sodium adsorption ratio (SAR).

species of the mixture.

From this finding, those involved in the partipatory research discussed the potential and economic importance of sunflower, and further investigation was set with the aim to reuse saline waste. Table 2 showed the mean yield of species grown with saline waste and its relation with the conventional systems (fresh water). In relation to the level of crude protein of elephant grass, it was found to increase with the use of saline waste, but experienced losses in the percentage of dry matter. It was found that there were losses in the yield of all species grown with water of saline waste, between 25.30 to 11.04% in relation to the growths using fresh water for irrigation (Table 2). However, once the vegetables yield losses are due to the effects of salinity of the saline waste, they are certainly compensatory for the gains made by the option of disposing the desalination waste appropriately, avoiding environmental impacts for disposing it in soil and water course.

Studies on the tolerance of various species to salinity have shown that, through adequate water management and cultivation practices, crops can be produced commercially with saline water (Caruso and Villari, 2004; Savvas et al., 2007; Al-Karaki et al., 2009). Thus, in the soilless farming, it is expected that crops provide a sustainable use for the reject brine and also a guaranteed food production in the communities where the desalination plants were implanted. Still referring to Table 2, only 11.04% reduction was seen in the percentage of dry elephant grass and an increase in protein content when grown with saline water. According Viega and Camarão (1994), the crude protein content should be above 7% for forage plant to maintain the smooth functioning of its physiological processes and also at the minimum for ruminants to have proper rumen fermentation. For herb salt (*Atriplex nummularia*), there is high dry matter production in saline environments, probably because it is a halophyte species such that apart from high tolerance to soil salinity, water accumulates large amounts of salts in their tissues, thus recovering the saline soils.

With regards to *Caatinga* species under irrigation with water brine (Sabiá- *Mimosa caesalpiniifolia* Benth e Juremapreta - *Mimosa tenuiflora*), a reduction in dry weight was observed in young plants in relation to irrigation with good quality water in the order of 35.93 and 52.74%, for the jurema black and thrush species. The production of seedlings of forest essences is a viable alternative for the use of the water of reject brine in desalinization, being one of the ways to retain possible residue. The desalinated water and the reject brine chemical characteristics are present in Table 3.

In accordance with guidelines of Ayers and Westcot (1999), it should be noted that the reject brine had high degree of restriction on use by salinity risk ($EC_w$ > 3.00 dS $m^{-1}$) and for specific ion toxicity ($Cl^-$ > 10 mmolc $L^{-1}$). It also had moderate degree for sodium (Na+ > 10 mmolc $L^{-1}$). However, it had no impact on soil water infiltration. The effect of salt and its toxicity risk can be reduced byallowing the agricultural economic cultivation of various species. This is possible by adoption of a strict management of water and soil, especially in selecting plants tolerant to salinity.

## Conclusion

From the results, there were yield losses in all species grown with water of saline waste, ranging from 25.30 to 11.04% in relation to the conventional irrigation systems (fresh water); but there was biomass. However, the vegetable growth was successful in the community, because it could change the resident's mind about the disposal and reuse of the saline waste.

The reject brine has use restrictions for irrigation purposes when managed improperly and its direct deposition on soil causes salinization of community areas, exacerbating the process of desertification.

## Conflict of Interests

The authors have not declared any conflict of interests.

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