The uncontrolled growth of *Eichhornia crassipes* (Mart.) Solms in the banks of São Francisco River in Petrolina (PE) and Juazeiro (BA) Counties, Northeastern Brazil

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Abstract:

The uncontrolled growth of aquatic macrophytes is a problem experienced by most Brazilian cities, regardless of their size. Such uncontrolled growth has generated serious social, cultural and environmental issues due to the lack of planning and infrastructure in urban areas. Thus, the aim of the current study is to assess the unplanned and uncontrolled growth of aquatic macrophytes such as *Eichhornia crassipes* (also known as water hyacinth) in Brazilian counties such as Petrolina (PE) and Juazeiro (BA); as well as to assess the factors contributing to this condition in the edges of counties located in the Northeastern semi-arid region. The results of the investigations conducted *in situ* in the banks of São Francisco River, in the edges of these two counties, have demonstrated the concern with their public policies regarding water resources, more specifically with the water of a National Integration River. It was possible seeing the excessive growth and proliferation of aquatic macrophytes (e.g., water hyacinth); damages to recreation, tourism and landscaping; the emergence of mosquitoes, larvae and other vectors; and changes in the diversity of plant and animal species (some native plant species, fish and other organisms were replaced). It is recommended using modern geographic information systems to estimate and monitor the size of water hyacinth populations in areas where they prevail.

**Keywords:** *Eichhornia crassipes*, São Francisco River, aquatic macrophytes.

INTRODUCTION

Problems resulting from the uncontrolled growth of aquatic macrophytes are experienced by most Brazilian cities, regardless of their size. Such uncontrolled growth has generated serious social, cultural and environmental issues due to lack of planning and infrastructure in urban areas. Petrolina and Juazeiro are two counties bordering the São Francisco River, which receives the sewage from several homes and restaurants, among others. Thus, the sewage from these counties is discharged into the sewage collection system without proper monitoring. Consequently, the nitrogen and phosphate compounds deriving from domestic and other sewage sources allow the growth of water hyacinth (*Eichhornia crassipes*) (Figure 1), and of other plant species such as *Pistia stratiotes*, *Salvinia auriculata*, *Polygonum*; among others, as well as of aquatic organisms belonging to different botanical classes, such as microalgae. These organisms and plant species may cause other environmental and health issues, since they are harmful to human health.

Therefore, based on the current investigation and on observations and studies conducted *in situ* in São Francisco River, it is possible stating and recording in the herein presented report that the questions to be answered in the current study approach the concern with the public policies of these counties focused on water resources, i.e., on the water of a National Integration River. It is worth highlighting that society does not seem to consider the river as an environmental good. Thus, the river has its sustainability compromised by such neglect, fact that leads to environmental impacts caused by mitigating plants growing in the riverbanks.

What is this impact about? According to CONAMA (1986), the term environmental impact is defined as "any change in the physical, chemical and biological properties of the environment caused by any form of matter or energy generated by human activities that directly or indirectly affect the health, safety and well-being of the population; as well as its social and economic activities, the biota, the aesthetic and sanitary conditions of the environment, and the quality of environmental resources".
Accordingly, the aim of the current study is to assess how the uncontrolled growth of aquatic macrophytes, mainly of the *E. crassipes* species (water hyacinth), takes place in Petrolina (PE) and Juazeiro (BA) Counties, as well as to assess the factors contributing to such condition in the edges of these counties, which are located in the Northeastern semi-arid region.

**MATERIALS AND METHODS**

**Describing the site:**

The São Francisco River Basin is considered the third most important Brazilian watershed and its total area covers approximately 638,323km² (8% of the national territory). It holds 503 counties and part of the Federal District (1,277km², i.e., 0.2% of the Basin), as well as six Federal Units, namely: Bahia (307,794km²; 48.2%), Minas Gerais (235,635km²; 36.9%), Pernambuco (68,966km²; 10.8%), Alagoas (14.687km²; 2.3%), Sergipe (7,024km²; 1.1%) and Goiás (3,193km²; 0.5%). The river is divided in four regions due to its large size and to changes in its physical features and relief, namely: Upper São Francisco, Middle São Francisco, Sub-middle São Francisco, which comprises part of the studied region (Petrolina – PE; and Juazeiro – BA), and Lower San Francisco (MMA 2006).

**Method**

The current study consisted in an *in-situ* analysis conducted in Petrolina (Pernambuco State) and Juazeiro (Bahia State) Counties, Northeastern Brazil. The observations were conducted in the edges of both counties in August 2016, and demanded 24 hours of hiking. Thus, the sewage directly discharged by both counties into the river was photographed for further recording. Subsequently, the literature on the subject was accessed.

**RESULTS AND DISCUSSION:**

**Knowing the Aquatic Macrophyte:**

*Eichhornia crassipes*; popular name: water hyacinth - belongs to family Pontederiaceae. This floating aquatic plant easily grows in hot climate regions such as Petrolina and Juazeiro. According to ESTEVES & CAMARGO (1986), the aquatic macrophytes in tropical regions grow throughout the year due to the favorable thermal and lighting regimes. *Eichhornia crassipes* is considered an opportunistic and/or widely distributed species (CAMPELO et al., 2012).

Thus, the water hyacinth develops in water bodies, because its growth can be accelerated or compromised, depending on the nutritional limitations caused by urban sewage and industrial effluents. The species was introduced in the hottest tropical regions of all continents in the late nineteenth century for ornamental purposes (CORRÊA 1926).

The plant morphology of the species allows seeing that its root system increases when it absorbs and accumulates pollutants and heavy metals through water filtration. *E. crassipes* is considered the most studied aquatic macrophyte species due to its ability to filtrate metals deriving from water bodies, because it is a hyperaccumulator of metals and pollutants (PAIVA et al., 2009).

**Positive and negative aspects concerning water hyacinth settlement in water bodies:**

It is worth emphasizing that water hyacinth helps the environment by releasing the oxygen (O₂) produced through photosynthesis into water bodies. However, the imbalance resulting from the excess of plants in the environment leads to competition for space. Thus, these excesses lead to shading in the river and it prevents the photosynthesis of algae submerged in the water. Consequently, the death of aquatic organisms generates excessive organic matter in decomposition, which is a process that consumes oxygen and generates toxic and corrosive gases, as well as unpleasant odors. On the other hand, the species helps improving the quality of water by removing the heavy metals from the environment it is in.

1. **Is it possible stating that the species is imbalanced?**

Yes, there is a clear competition for physical space involving other native aquatic macrophytes and different life forms. The riverbanks have been uncharacterized and the riparian vegetation along
the river no longer exists, mainly in the urban edges of Petrolina (PE) and Juazeiro (BA). Thus, the lack of such vegetation promotes sediment transport, new islands formation and drastic water level reduction, facts that leave the banks in the two edges dried for months (Figure 2).

2. What are the positive aspects the plants in the picture bring to the water course?

The literature (BEZERRA; SILVA & LOPES, 2007; MEES, 2006; SAMPAIO & OLIVEIRA, 2005; and EL SAYED, 1999) mentions many positive aspects of *E. crassipes* (water hyacinth) and highlights its economic and environmental potential for biomass exploitation, for organic fertilization and composting, as well as for animal diet component.

According to the literature (AZEVEDO NETO, 1988; TRIPATHI and SHUKLA 1991), water hyacinth is able to remove considerable amounts of phenols, heavy metals and other substances such as 0.7 mg Cd/OS (dry weight) and 0.5 mg Ni/g (dry weight) from the water. There are also data records indicating significant reduction of BOD (Biochemical Oxygen Demand), nitrogen and phosphorus, suspended solids, alkalinity, ammonia, hardness, dissolved organic carbon and of coliforms under laboratory conditions in the treatment of domestic and industrial sewage using tanks containing water hyacinth.

Water hyacinth can be used to treat water bodies due to its low cost and reduced energy expenditure. There are also records concerning the use of its biomass as organic fertilizer in rivers and lakes, as well as in energy production (biogas or direct burning), animal diets, paper production due to its cellulose, among others (ESTEVES, 1991; THOMAS & ESTEVES, 1985).

According to BORTOLOTTOI & NETO (2005), this plant species has ornamental purposes. The so-called "lilypad" can be picked in watercourses in the region at any time of the year to be used in decoration. During the flood season in Paraguai River the plant gets softer, which favors its use by craftsmen. It is necessary using canoes to pick up the plant during the floods, because the water level gets too high. However, during the dry season, the collector can get into the water, since it stays at knee height. The petiole of the emerging leaves is used for handicraft. The leaves of adult individuals 50 cm tall or taller are cut. Young individuals are not used, as well as individuals showing inflated petiole. Sharp scissors or knives, as well as small machetes, can be used to cut the leaves. After the leaves are cut, the petioles are separated from the blade, which is discarded. The petioles are placed in large plastic bags in order to be transported. The previously mentioned literature cites the use of water hyacinth for handicraft purposes.

3. What are the negative aspects aquatic macrophytes bring to the river and to the riverside population?

The negative effects generated by aquatic macrophytes mainly result from the process known as eutrophication. By walking along the edge of both counties investigated in the current study, it was possible easily seeing this process taking place in the banks of São Francisco River. The eutrophication process entails the following imbalance aspects (Figures 3):

1. The excessive growth and proliferation of aquatic macrophytes (e.g., water hyacinth);
2. Damages to recreation, tourism and landscaping;
3. Emergence of mosquitoes, larvae and other vectors;
4. Changes in the diversity of plant and animal species, since some native plant species, fish and other organisms are replaced;
5. Organic decomposition, increased evaporation, dissolved oxygen depletion and anoxia;
6. Water quality loss because of unpleasant odors and changes in the chemical, physical and biological properties of the water;

Although the negative impact water hyacinth has on the river results from its increasing and uncontrolled growth caused by the excessive discharge of open sewage into several points of the river edges in Petrolina and Juazeiro, the water hyacinth population cannot overcome the excess of pollution.
Therefore, the public authorities must prioritize public policies concerning the manual control of the species, i.e., it is necessary conducting the proper planning and management of the species’ biomass in order to enable the aquatic macrophyte to efficiently play its filtering role in sewage treatment. Thus, the planning, control and mechanical management (removal) of its biomass is the most viable way of doing so.

What are the prevailing positive and negative aspects?

It is not possible seeing and measuring the positive aspects of the environmental role played by aquatic macrophytes when the aquatic ecosystem is imbalanced. The problem does not lie on water hyacinth, but on the valorization, respect and scientific knowledge about the hydrological dynamics of São Francisco River, which is a theme that remains little explored.

According to Siqueira FILHO et al., (2015) the São Francisco River has been the central theme of many studies in the most diverse fields of economic, social, environmental and cultural sciences. Although the importance of the National Integration River, which covers 7 states and 503 counties, seems to be consensus, the monitoring activities performed in the river are innocuous and the revitalization activities are incipient. Given the heterogeneous nature of São Francisco River, it is necessary taking integrated actions to promote its sustainable development. The time of making major diagnoses has passed and the time to take actions in the basin is pressing.

Thus, it is worth emphasizing that the species E. crassipes, which mainly prevails (proliferates) in the urban portion of São Francisco River, cannot be taken as the "scapegoat" of the imbalance in one of the most important Brazilian rivers (Figure 7). On the contrary, water hyacinth is an excellent ecosystem "health" bioindicator and it plays an important role in the monitoring of imbalance systems conducted by control and inspection bodies. This aquatic plant shows remarkable vegetative growth in nutrient-rich polluted environments and it amplifies the aquatic system eutrophication process in areas wherein the discharge of untreated domestic and/or industrial sewage is continuous. Thus, the herein described process results in an eutrophic water body, which would be originally oligotrophic, given its physical, chemical and biological properties.

RECOMMENDATIONS

In short, the current study was an attempt to show the situation in the edges of São Francisco River covered by aquatic macrophytes, mainly by water hyacinth, as well as to provide an overview of this National Integration River based on scientific information (Figure 8). The current study recommends the following propositions to be encouraged and adopted by the federal, state and municipal bodies, through a conduct adjustment term aiming at providing technical solutions able to assure the monitoring and use of the species, as well as to generate employment, income and sustainable development, since:

1 – Modern geographic information systems should be used to estimate and monitor the size of water hyacinth populations in the areas wherein they prevail;
2 – Based on the continuous monitoring, which must take place for at least 24 months, it would be possible to continuously and gradually remove the plants from the river on a periodic basis using sustainable methods rather than using large machines and tractors that would compact the soil and prevent the natural regeneration of the riparian forest;
3 – The water hyacinth plants removed from the river should be mainly used to cover the exposed soil on the riverbank wherein the problem is observed, whereas the surplus could be used in an experimental biogas production plant. Such biogas could be used by companies located in the riverbank as a way to encourage the sustainable use of natural resources so far taken to dump sites;
4 – Using legal means to promote degraded area recovery (RAD) through the immediate planting of native species belonging to the riparian forests of São Francisco River. Such planting should not be restricted to woody species, it should rather adopt a set of modern riparian forest restoration techniques, according to scientific and technological criteria;
5 – Pernambuco and Bahia states should provide all legal and financial means to implement an immediate restoration plan in the areas most invaded by water hyacinth plants. Such plan is crucial.
since this aquatic plant belongs to a species typical of heliophilous environments and has its population diminished in shady and oligotrophic environments;

5 – The Reference Center for the Recovery of Degraded Caatinga Areas (CRAD / UNIVASF) has all the technology and scientific knowledge necessary to guide the procedures to be adopted in order to mitigate the visual and economic impacts on the urban area of São Francisco River.

REFERENCES


Fig. 1 - General view of Baronesa (*E. crassipes*) on a stretch of the shore of the São Francisco River, on the border of Petrolina - PE.
Fig. 2 – Untreated domestic sewage released in the edge of Petrolina, São Francisco Riverbank, on August 13th, 2016.

Fig. 3 - Sewage in the border of Juazeiro-BA, favors the accelerated process of eutrophication, on August 13th, 2016.