Viability of reutilization of water through previous treatment with aquatic macrophytes in irrigation waters

VIABILIDADE DE REUSO DA ÁGUA ATRAVÉS DE TRATAMENTO PRÉVIO COM MACRÓFITAS AQUÁTICAS EM ÁGUAS DE IRRIGAÇÃO

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ABSTRACT

Reuse of water is today an important resource to reduce the wasting of hydric resources, and conserve them. Experimental studies using aquatic macrophytes for previous treatment of the water, consisting of surveying the quality of water proceeding from the irrigation of the seedlings vivarium at V.C.P Florestal S.A., after the introduction of aquatic macrophytes, as to remove the nutrients, aiming at reutilization of the water in the acclimatization squares of the vivarium. The employed methodology was field survey, in which were researched the bibliography and related documents, visits to professionals, and field study that enclosed the choice of the species, collecting of Pistia stratiotes and Eichhornia crassipes, weighing for growth verification, monitoring the plants' development, water collection for analysis and handling of aquatic macrophytes. There was a verified enhancement in the analyzed water's quality after the introduction of plants in the infiltration lake through the reduction of concentration of parameters DBO, DQO, pH, Cadmium, Nickel and Iron. Some parameters could not be reduced, such as Boron, Copper, Manganese, Zinc and Lead, all of them coming from fertilization, due to the experiment conditions. However, these elements had greater concentrations in previous analysis, before the plants were introduced.

KEYWORD

Reuse of water. Hydric resource. Aquatic macrophytes. Management.

RESUMO

O reuso da água é hoje um importante recurso para reduzir e conservar os recursos hídricos. O estudo experimental utilizando as macrófitas aquáticas para tratamento prévio da água, consistiu no levantamento da qualidade da água proveniente da irrigação de mudas do viveiro da VCP florestal S.A., após a introdução de macrófitas aquáticas para remoção de nutrientes, visando o reuso dessa água na irrigação das quadras de aclimatação do viveiro. A metodologia empregada foi de levantamento de campo, onde foram pesquisadas literaturas, documentos e foram realizadas visita a profissionais da área e estudo de campo que abrangeu a escolha das espécies, coleta da Pistia stratiotes e da Echhornia crassipes, pesagens para verificação do crescimento, monitoramento do desenvolvimento das plantas, coleta de água para análise e manejo das macrófitas aquáticas. Pode-se verificar que houve melhora na qualidade da água analisada após a introdução das plantas na lagoa de infiltração, através da redução nas concentrações dos parâmetros DBO, DQO, pH, Cádmio, Níquel e Ferro. Alguns parâmetros não puderam ser reduzidos, como o Boro, Cobre, Manganês, Zinco e Chumbo, provenientes da adubação, em razão das condições do experimento. Estes elementos apresentaram concentrações superiores as apresentadas nas análises anteriores a introdução das plantas. Algumas hipóteses foram levantadas para estudos futuros, como elevada concentração de nutrientes no período da coleta da água devido a ausência de

chuva e baixa absorção de alguns elementos por parte das macrófitas aquáticas.

Palavras-Chave

Reuso da água. Recursos hídricos. Macrófitas aquáticas. Gerenciamento.

Introduction

The shortage of water resources, as well as its degradation, creates the need for developing alternatives for reducing water pollution, in order to increase the availability of high quality water and, at the same time, reducing the production costs. Environmental management and the elevated water consumption in the seedling vivarium make decreasing the consumption and creating strategies for its rational use an urgent issue. The reuse water, in this context, is presented as a potential rationalization alternative, specially for agricultural uses. Lavrador Filho (1987) apud Brega Filho e Mancuso (2003, p.25), the concept of the reuse of the water as "the water exploitation previously used, [...], to supply the necessities of other benefits, also the original". The agricultural sector in Brazil is priority in terms of reuse of the water due to the consumption of approximately 70% of the total water and the increasing scarcity of the hydric resources (OLIVEIRA, 2003). "The aquatic plants are most efficient in the treatment of effluent for presenting high primary productivity and high capacity to storage nutrients in biomass" (GOPAL (1990) apud CAMARGO; PEZZATO; HENRY-SILVA, 2003, p.62). "A system treatment of effluent in aquatic plants can be defined as a natural process, where the plants have main paper in the removal and the storage for long stated period of the urbanistic residues" (BRIX (1993) apud PETRUCIO; ESTEVES, 2000, p.2).

The Votorantim Celulose e Papel (VCP) florestal S.A. vivarium at Jacarei (SP), is responsible for the production of eucalyptus and native tree species seedlings to supply raw materials for pulp and paper manufacturing and reforesting the company's farms. After the irrigation, the water is stored in an infiltration pound, which was previously a storage tank for irrigation water. The water that remained after the irrigation was released into the neighbor property, a pasture farm. Due to soil erosion caused by the water, the vivarium was fenced, and water storage tanks were built next to the acclimatization squares and the water was sent to one of the pounds after irrigation. The pound had its coating removed, and the water began to infiltrate the soil. It comes to the pound by two entrances, after they pass through the vivarium.

This study was divided in field data collecting and experimental study. The study aimed at the evaluation of the quality of the water stored in the infiltration pound after the introduction of aquatic macrophytes for reutilization on irrigating the seedlings of the acclimatization squares, where the contamination risk is reduced, since the water contains nutrients coming from fertilization and pathogenics that are found in the vivarium. Treatment of water destined to the infiltration pound was made in experimental scale, using two species of aquatic macrophytes for a maximized nutrient removal. The water analysis after the treatment was made concerning physical-chemical standards and the growth evaluation was made through cell culture analysis.

Objectives

Evaluating quality of the water stored in the infiltration pound, after introducing the two aquatic macrophytes species, for reutilization on irrigation for seedlings at the acclimatization squares of the seedlings vivarium of the VCP florestal S.A. company, at Jacareí unit.

Materials and methods

This study was divided in data collection and field study. For the data collection, a climactic characterization of the studied area was made, as well as a description of all the processes of the seedlings vivarium, a water consumption data collection at the vivarium, and a history of the analyses made in the water. For the field study, the following steps were made:

Choosing the aquatic macrophytes species

The species were selected through contacts with professionals who work at the area. The chosen species were Eichhornia crassipes, commonly known as Aguapé (water hyacinth) and Pistia stratiotes, known as Alface d' água (water lettuce). This species reoxigen the water and acts as a secondary period of training of the stations of treatment of sewer that inject air and form silt. In the roots propitiates the proliferation of the community of aerobic bacteria, seaweed, protozoários, small crustaceans and larvae of insects and clams that are equivalent to the silt activated in the conventional secondary stations (LUTZENBERGER, 1985). The system to radicular functions with mechanical filter and adsorv material in particles (organic and mineral) existing in the water (MANFRINATO (1991) apud POMPEO, 1996). This species transfer atmospheric oxygen for the root, promoting the aeration of the layer of water next the roots and process to desnitrification that removes nitrogen of the water (FERREIRA, 2000).

Specimen collecting

Collecting of the selected species was made in August, 2004. Sixteen specimens of P. stratiotes were collected at Pindamonhangaba (SP) and 38 specimens of E. crassipes were collected at Mogi das Cruzes (SP). After the collecting, the plants were washed in current water, to remove any adhered material, dried in a sieve for ten minutes, to remove the excessive water, were weighted to determine the initial mass and placed in the infiltration pound in PVC fenced squares of 1m2, separated by species, avoiding mixing and competition and easing the handling.

Weighting and growth

The growth of the aquatic plants during the adaptation period was supervised through each species mass and individual counting for four weeks. After this period, the plants, due to their growth, required an expansion in the PVC fences, which area went from 1m2 to 7m2. Shortly after, thefences' area was increased from 7m2 to 30m2, when the removal of the plants began.

Water collecting and analysis

Water collecting was made using method NBR 9898/97. Water analysis was mad by Oikos Controle Ambiental Ltda., using the Standard Methods for Examination of Water and Wastewater and CETESB methods. The analyzed parameters were: solidity, sodium, chlorate, sulphate, sílex, magnesia, chloride, nitrogen, nitrogen ammonia, nitrate, nitrite, potassium, organic total carbon, calcium, total phosphorous, reagent phosphorous, boron, copper, total iron, manganese, zinc, aluminum, cadmium, nickel, lead, molybdenum, DBO, DQO, sulphur.

Handling the aquatic plants

After the plants were removed from the fences, about 50% of them were placed in infiltration pound 2, which wasn't being used at the time. The removal was made during the last four weeks of the study with the aquatic plants, due to their accelerated growth and to the physical evidences that their decomposition period.

Results and discussions

Weighting

Concentrations more righ of nutrients can reduce the taxes of absorption and growth of plants (PETRUCIO; ESTEVES, May 2000). The initial mass of the species was of 388,5g for 16 specimens of P. stratiotes and 771g for 38 specimens of E. crassipes. The presence of periphyton, aquatic invertebrates and decomposing organisms could be observed. The biomass variation each ten days was of 292,55g for P. stratiotes and 289,6 for E. crassipes. Figure 1, below, shows the results obtained in the specimen counting for both aquatic macrophytes species studied during the adaptation period:

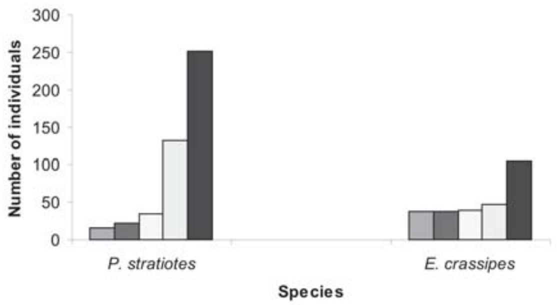

Figure 1 – Specimen counting results

According to the results observed in the graphic above, P. stratiotes had a bigger number of specimens, probably due to the fact that its buds are released much faster than the E. crassipes buds. Mass-wise, E. crassipes had a higher value than P. stratiotes, according to the consulted bibliography. However, both species showed similar amounts relating to the biomass, as shown in Figure 2 below:

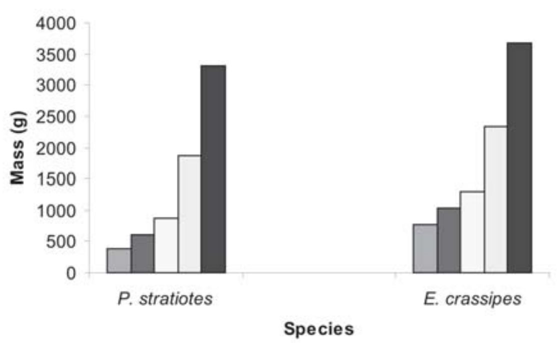

Figure 2 – Species biomass results

AQUATIC PLANTS' GROWTH

After the adaptation period, the growth of the aquatic plants was monitored through observation. The great availability of nutrients in the water could be confirmed by the short length of the plants' roots, which was an hypothesis considered in the beginning of the study, and also the reason for choosing the aquatic plants for a preliminary treatment of the water. Intra-species competition could be observed too, as well as a vertical growth of E. crassipes near the end of the study. The plant needed a 15 day period from beginning to end of the study to duplicate. For P. stratiotes, the duplication time took 15 days at the beginning at the study and seven at the end.

WATER QUALITY ANALYSIS

Water samples to be analyzed were collected 45 days after the species were placed in the infiltration pound. Table 1 (below) shows the main results obtained in the analysis.

Table 1 – Analysis of water from the infiltration pound, before and after aquatic microphytes introduction

Parameters	History 2004	Analysis after introduction
DQO (mg O_2/L)	34	20
DBO (mg O_2/L)	9,5	5,5
pH	6,65	6,2
Boron (mg/l)	0,20	0,4
Copper (mg/l)	<0,01	0,16
Zinc (mg/l)	0,035	0,78
Cadmium (mg/l)	<0,001	<0,0006
Nickel (mg/l)	<0,01	<0,008
Plumb (mg/l)	<0,01	<0,02

For any end, the reuse of the water depends of the physical, chemical and microbiological quality. Other factors would be the quality of the generating source, the treatment the residuary water, the trustworthiness in the treatment processes, the project and the system of distribution for this water can be used for the foreseen purpose. The chemical constituent that present potential problems in the irrigation are the salinity, the permeability of ground and the specific ions toxicant (CROOK, 1993). According to Paganini (2003, p.353), "the risks of reuse agriculturist are [...] the contamination for metals weighed, the biological contamination and the deleterious potentiality of the leaching of elements through the ground until underground sheets".

As the table above shows, DBQ, DBO, pH, cadmium and nickel parameters were reduced, as expected. Reduction in these parameters indicated an improvement in the water quality, pH reduction showed the beginning of the plants' decomposing process, which was confirmed by their physical characteristic during this period.

On the other way, parameters borum, copper, zinc and plumb, had an increase. Three possibilities were raised to explain these results. The first one is that these elements were introduced in the pound through fertilizing, and in the day the water was collected for analysis, with hot and dry weather and no rain, these elements' amounts were raised, even when being absorbed by the plants. The second possibility is that the plants don't absorb these elements in large amounts, which allowed their concentration in the infiltration pound. The third hypothesis is that the plants may have been collected from their natural environment saturated with these elements and, instead of absorbing, they released them on the water. The raised possibilities couldn't be confirmed until the end of this study.

Analyzed parameters residual chlorine residual, nitrate, sodium, manganese, chlorate, sulphate, total iron e aluminum couldn't be compared with any history of analysis of the pound's water because none of these parameters was analyzed before. Therefore, a comparison was made with modern regulations. All the cited parameters, except for the manganese, were inside the amount determined by laws and/or recommendations in use. The amount of manganese obtained was 0.11mg/l, when the legally permitted amount is 0,05mg/l.

Parameters total nitrogen, nitrogen ammonia, nitrite, total phosphorous, reactive phosphorous, potassium, calcium, magnesia, sulphur, silica, molybdenum e total carbon organic could not be compared due to the lack of a previous history and, until the end of this study, the lack of regulation literature. The reduced forms (organic and ammoniac nitrogen) prevailed due to the proximity to the pollution source, fertilization. The elevated amount of potassium occurred because of high concentration, since there wasn't any rain during that period.

Some parameters could be compared with the analysis of the water from wells, which is used for irrigating the seedlings. Table 2 (below), shows these results:

Table 2 – Analysis of water from infiltration pound after the plants' introduction and from the storage tank for irrigation

Parameters	Storage tank	Infiltration pound
DBO (mg O_2/l)	<5,0	5,5
DQO (mg O_2/l)	<5,0	20
pH	6,35	6,2
Boron (mg/l)	<0,01	0,4
Cadmium (mg/l)	<0,001	<0,0006
Plumb (mg/l)	<0,01	<0,02
Copper (mg/l)	<0,01	0,16
Nickel (mg/l)	<0,01	<0,008
Zinc (mg/l)	<0,01	0,78

As the table shows, pH, cadmium and nickel showed values lower than those found in the storage tank, which allows its utilization, based on these parameters. DQO and DBO presented very close values. If the area occupied by the plants was larger, these values could be reduced to the numbers needed for utilization, as cited by Beyruth (1992), "if the area occupied by the plants were larger, there would be a reduction on nutrients". Boron, plumb, copper and zinc were found in amounts bigger than those obtained in the storage tank, which compromised the water's utilization, and could probably be explained by one of the three possibilities previously cited.

Handling

Handling of the aquatic plants began 60 days after they were introduced in the infiltration pound, due to the accelerated and excessive growth of the specimens in the PVC fences, which at that point had already been expanded to 30m2. Besides, because of the restricted space, the plants began to decompose, which created the necessity of the handling, to renew the plants. About 40 to 50% of the specimens were removed from the fences during four weeks. They were put in infiltration pound 2, which wasn't being used. The removal accelerated even further the plants' growth. E. crassipes presented a slower decomposing process than P. stratiotes, as per the consulted biograph

Conclusions

At the end of this study, it can be concluded that the growth rate for both species was elevated, with some differences between them. E. crassipes had more mass, while P. stratiotes had a faster duplication time. Analysis on the water from the infiltration pound after introducing the aquatic macrophytes showed an increase on the water quality, based on parameters DBO, DQO, pH, cadmium, nickel and iron, all of them through reduction. The improvement on the water quality could also be confirmed by the elimination of the "green layer" (algae), which previously covered all the infiltration pound. It is a characteristic of eutrophized environments and it improves the water transparency.

The same reduction wasn't achieved, and there was a increase in the concentrations of barium, boron, copper, manganese, zinc and plumb, and the most probable alternatives, which can be studied in a continuation of this study are: a) Elements resultant from fertilization made in the vivarium, by the time the water was collected were highly concentrated due to the lack of rain in the period; b) Concentrations were high due to the plants' decomposing period, which favored the reintroduction of these substances in the environment, along with the ones discharged during fertilization; c) The plants can't remove these elements from the water or only are able to remove a certain amount, and in this case the quantity would be higher than their capacity for removal.

A study in a controlled environment, where the time the water stays in contact with the aquatic microphytes can be closely monitored, a previous analysis on the collected plants can be done, as well as a longer time for study and a bigger area to be occupied by the plants, among other variables, might enlighten the pending questions and provide information and conditions for a better handling of the system and allow the reutilization of the vivarium irrigation water to become reality.

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