PHYTOREMEDIATION AGRO INDUSTRIAL WASTEWATER OF USING MACROPHYTE *Eichhornia crassipes*

DANIELE ARAUJO **CANAZART**[1], ADRIELI RODRIGUES DA COSTA **NUNES**[2], MARLUCE **SANCHES**[3], HÉLIO **CONTE**[4*]

1.Biologist and Biotechnology Specialist; Master student of the Postgraduate course in Environmental Biotechnology of the State University of Maringá;**2.** Technologist in Biotechnology; Master student of the Postgraduate course in Environmental Biotechnology of the State University of Maringá (UEM); **3.** Biologist, Specialist in Biotechnology and Master in Environmental Biotechnology. State University of Maringá (UEM);**4.**PhD in Biological Sciences by State University of São Paulo Júlio de Mesquita Filho.

Colombo Avenue, 5790. Bloco H67 Sala 07, Maringá, Paraná, Brazil. ZIP CODE: 87020-900. hconte@uem.br

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ABSTRACT

The agroindustrial sector in Brazil has been increasing the production of food. The poultry slaughterhouses constitute one of the sources of pollution in this sector through its effluents that have high loads of polluted water, including organic load being responsible for causing environmental damage. The effect of these polluting effluents brings as consequences of the ecological imbalance. The agroindustrial wastes are not disposed of properly, because of this, it is extremely important to minimize waste through cost-effective practices. An alternative would be the use of aquatic plants with the purpose of decontaminating polluted environment by phytoremediation. With this technique, it is possible to supplement the removal of pollutants and promote the recovery of water which has been contaminated by organic and inorganic substances. This review aims to address the practice of aquatic phytoremediation using macrophyte *Eichhornia crassipes* popularly known as Aguapé an alternative in the treatment of waste water from poultry slaughterhouses, aimed at sustainably to environmental preservation. We used databases SciELO, PubMed, Scince Direct to select the articles published on the subject. Therefore, phytoremediation by E. crassipes can be considered a viable alternative to complement the treatment of slaughterhouse wastewater birds.

KEYWORDS: Slaughterhouses. Water hyacinth. Organic Pollutants.

1. INTRODUCTION

Phytoremediation can be defined as the use of plants to remove pollutants from a contaminated environment and is seen as a well-established environmental protection technique[1].

The basic idea that plants can be used for environmental remediation is very old and cannot be attributed to a particular source. The removal of nutrients of high organic resistance present in the effluents is a relevant activity, which requires research and development, since the agroindustrial effluents are not disposed of correctly in many countries, and the pollution of surface water bodies is a problem common[2].

The disposal of waste, nutrients and contaminants from industrial waste has generated several problems, leading to eutrophication of the reservoirs, increasing the deposited sediment load, as well as the concentration of heavy metals and other toxic elements in the environment[3].

The polluting effect of these types of waste is reflected in the ecological imbalance due to the high content of organic matter and microbiological load, which are disposed of incorrectly in the environment and can cause serious problems to the environment[4].

In this context, the objective of this work was to relate the practice of phytoremediation using the aquatic macrophytes *Eichhornia crassipes*, in order to find alternatives that complement the treatment of agroindustrial effluents to reduce the environmental impact caused by this sector.

2. MATERIAL AND METHODS

It was carried out a survey of the periodicals, that composed the theoretical body, indexed in the bases SciELO, Pubmed, Scince Direct. This survey was complemented with dissertations and theses available in the Digital Library. After the initial survey of the topic, since it was a very wide universe, and in view of the objectives of the study, some keywords were selected according to the descriptors in the Bireme Health Sciences base (DECS), such as: Environmental Biodegradation; Slaughterhouses; Aguapé; Phytoremediation; Organic Pollutants and Macrophyte. Thus, proving the importance of the aquatic macrophyte *Eichhornia crassipes.*

3. LITERATURE REVIEW

Agroindustrial sector and effluents derived from its activity

The agroindustrial sector, especially the poultry slaughtering segment, has been highlighted by the high productivity of food, not only worldwide, but also in Brazil. This highlight is evidenced by the technological innovations, due to the development of new breeding and slaughter techniques, as well as advances in genetic improvement.

Brazil is the third largest producer of chicken meat in the world with 12,691 tons, behind only the United States with 17,254 tons and China with 13,000 tons. Brazil is currently the largest exporter of chicken meat with 4,099 tonnes at the front of the United States with 3,297 tonnes and the European Union at 1,100 tonnes[5].

The states of Paraná and Santa Catarina have shown leadership over the years, with estimates of slaughter in June 2015 with 30.26% and 16.68%, respectively Paraná, Santa Catarina and Rio Grande do Sul. Industries in the poultry sector, with Paraná being the largest producer of chicken meat (slaughtered heads), according to data collected in June 2015[6,7].

Due to high productivity and growing export volumes, poultry slaughterhouses are one of the sources of water pollution. The residues generated in the poultry industry are voluminous, occurring from the production stage in the manufacturing process until the goods leave the shipment[8].

The increase in production is directly related to a larger amount of effluent coming from it, and consequently there is an increase in potentially polluting sources[4].

Treatment of agroindustrial effluents

Among the different types of effluents, slaughterhouse evictions can be treated by the same processes as those employed for domestic sewage, through anaerobic processes, high-rate biological filters, activated sludge[9]. In addition, the same de-polluting effects can occur with use of rotating biological disks and by aerobic lagoon and stabilization systems. However, these processes are not always able to remove, at levels acceptable by current legislation, the concentration of these nutrients and the soluble organic matter present in the waste[10].

Many companies seek to fit in, including in their environmental policy strategies, a healthy relationship with the community, reduced environmental costs and risks, and even meet the requirements imposed by potential markets for the business, the vast majority of wastewater treatment systems Is composed of sequentially arranged treatment units in which separation operations and transformation processes of the constituents present[11].

The use of phytoremediation would be an alternative to complement the treatment of the effluents that do not always meet the parameters required by the legislation with the objective of minimizing the resistance of organic content and mainly, returning the water in conditions to be reintegrated. The use of aquatic macrophytes for the treatment of effluents is an apparently proven alternative and used on an industrial scale[12]. The use of phytoremediation contributes to the maintenance of water quality through the processing of organic matter, chemical residues and the reduction of the sediment load discarded in the receiving bodies[13].

Among the advantages of this technique is its ability to be performed in situ, besides having low cost, low environmental impact, minimal dispersion of contaminants, easy removal of plants and plant organs and its control process is more simplified[14]. Others Benefits that can also be achieved with this technique would be the ability to phytoremediate several elements in the same place, reuse for other purposes, and be acceptable to society[15].

Many authors have described phytoremediation as an effective tool for reducing a wide range of pollutants such as heavy metals, nickel, lead and zinc[16], industrial effluents as from a rubber processing industry[17] and drugs[18].

Mechanisms by which the plant performs the phytoremediation process

The phytoremediation process can act in two ways: direct or indirect, in the reduction or elimination of pollutants. In direct phytoremediation the pollutants are absorbed and accumulated or transformed in the tissues, in which case the metabolization results from the transformation of the initial compound or mineralization of the same. In the indirect form, plants remove pollutants from the water, reduce pollution or when the plant establishes a favorable medium for the increase of microbial activities that eliminate the pollutants[19].When introducing aquatic plants, physical and chemical analyzes, as well as knowledge about the vegetative cycle, should be considered. This knowledge supports the conscious use of species for the conservation of natural systems[20]. The criterion for choosing the macrophyte to be used in a phytoremediation process must be associated to its availability, in the region where the system will be implanted[21].

*Eichhornia crassipes (*Aguapé)

The diversity of aquatic species in Brazil is great. Some common species in the rivers and lagoons of the country are the *Eichhornia crassipes* (popularly known as Aguapé, water hyacinth, baronesa, queen of the lakes), *Pistia stratiotes* (lettuce d´Water), and among other genera Salvinia, Water frog, Marrequinho, Frog and Murerê grass) and Potamogeton, and one of the most promising species for industrial phytoremediation is the *Eichhornia crassipes*[22].

The aquatic macrophytes of the species *E. crassipes*, belonging to the family *Pontederiaceae*, are floating aquatic plants classified as monocotyledons. Its spread is common in regions of tropical climate. In Brazil, this species occurs both in natural aquatic ecosystems and in environments impacted by anthropic activities, where they have a high growth rate and produce large amounts of biomass[23].

Characterized as a perennial, fixed or floating plant, with a short stoloniferous stem, the size of the numerous roots has a linear relation with the plant biomass and the length of the petiole, pendulous and feathery. The plant has a rosette of leaves with short and thick petioles, which serve as floats, and orbicular or reniform lamina, glabrous; Its flowers are blue, with a yellow matrix, arranged in spikes, which can occur almost all year round[24].

Its reproduction occurs by the vegetative form or through seeds. Due to its growth characteristics, this species is the most feared aquatic invasion of dams, canals, lakes and rivers in several countries. Plants of this species seem to fit better in deeper water because the structure of the plants depends on the leaves as floats[25].

The biomass production of water hyacinth varies according to the growth rate, under optimum conditions, on average it reaches 5% per day. This macrophyte has the ability to fix nutrients in your tissues in excess of your needs, as well as chemical elements that are foreign to your metabolism. The root system of the water works as a mechanical filter that retains the particulate material (organic and mineral) existing in the water, allowing an environment rich in fungi and bacteria activities, becoming a depollution agent reducing the BOD, the rate of coliforms and the turbidity of polluted waters[26].

In many countries, one of the most widely used ecological alternatives is the use of aquatic macrophytes *E. crassipes* as a phyto-purging agent, as well as having desirable characteristics in phytoremediation processes such as high development velocity in polluted waters; High capacity to absorb heavy metals, explosive radionuclides and organic and inorganic pollutants[28].

The removal of organic matter (BOD and COD) and the removal of nutrients are some of the main objectives of phytoremediation of agroindustrial effluents.

4. DISCUSSION

Use of *E. crassipes* in the phytoremediation of effluents contaminated with organic matter

In the literature, several studies evaluated the efficiency of the use of aquatic macrophytes in the treatment of different types of effluents with the objective of removing organic matter. The efficiency of *E. crassipes* and of another aquatic macrophyte was observed to *Pistia stratiotes* (lettuce d ' Water) in the treatment of raw domestic fluent in boxes of asbestos and polyethylene. The results obtained showed that *E. crassipes* was more efficient in the removal of BOD and COD when compared to *P. stratiotes*. However, the removal obtained with this treatment did not meet the parameters determined by the legislation, which implies that this system can be used, but must be associated with other techniques to increase its efficiency[29]. Effluents from the refrigerator were treated in a system with *E. crassipes*, the results showed that the plants used in the after-treatment of the refrigerator effluent, were efficient in reducing nutrients, mainly nitrogenous forms, total phosphorus and increased oxygen dissolved in the effluent treated[30]. *E. crassipes* was evaluated for the removal of nutrients and organic matter, applied in situ in a slaughterhouse and refrigerator effluent treatment system. The results obtained were positive for the removal of organic matter (BOD and COD) and nutrients (total N, N-ammoniacal and total P). With these works they found that the process is viable and efficient. However, for the treatment to be positive, there is a need for a control of biomass removal, which must be conducted in an appropriate manner according to the development of the plant[31].

The treatment of aquatic ecosystems, polluted by means of aquatic macrophytes, besides presenting low cost, reveals the possibility of reuse of the biomass produced. Depending on its composition, it can be used as animal feed, fertilizer, energy generation (biogas or direct burning), ethanol production, papermaking, protein extraction for use in feed, production of ecological building materials, handicrafts among others[32,33].

The effectiveness of phytoremediation depends on some care to be analyzed, such as the size of the contamination area of the soil or water, introduction of the plant, the capacity of the contaminant in relation to the root of the plant, the availability of the plant to prevent, Absorb or accumulate the contaminant in its tissues, the luminosity and the set of abiotic and climatic factors[34]. Like all existing methods of aquatic decontamination, phytoremediation has advantages and disadvantages. The disadvantages or limitations can be considerable, with slower results, related to the growth and development of the plants, depending on the climate and high concentration of the toxic substances, damaging plant growth[35].

5. CONCLUSION

Considering that not all plant species develop in contaminated environments, *E. crassipes* stands out because it has phytoremediation characteristics for agroindustrial effluents, and can be indicated to complement the treatment of this type of effluent. Thus, phytoremediation using aquatic macrophyte may be a sustainable alternative to minimize the environmental impact generated by slaughterhouse effluents, since treatment processes do not always eliminate all contaminants.

REFERENCES

[01] Priya ES, Selvan PS. Water hyacinth (*Eichhornia crassipes*)–an efficient and economic adsorbent for textile effluent treatment–a review. Arabian Journal of Chemistry 2014; 1-11. In Press.

[02] Moo-Young, M. Comprehensive biotechnology. 2nd ed. Waterloo: Elsevier; 2011.

[03] Romitelli, M. S. Remoção de fósforo em efluentes secundários com emprego de macrófitas aquáticas do gênero *Eichhornia*. Revista DAE 1983; (133):66-88.

[04] Pardi, MC, Santos IF, Souza ER, Pardi HS. Ciência, higiene e tecnologia da carne. 2ª ed. Goiânia: Ed. da UFG. 2006.

[05] Associação Brasileira de Proteína Animal. Estatísticas do Mercado Mundial em 2014. [acesso 4 ago. 2015] Disponível em: http://abpa-br.com.br/.

[06] Sindicato das Indústrias de Produtores Avícola do Estado do Paraná. Produção de frango junho de 2015. [acesso 20 jun. 2015] Disponível em: http://www.sindiavipar.com.br/.

[07] Brasil. Ministério da Agricultura Pecuária e Abastecimento. Concentração de maiores indústrias no setor aviário 2015. [acesso 21 jun. 2015] Disponível em: http://www.agricultura.gov.br/.

[08] Karpinski G. Sistema de Gestão Ambiental-SGA: uma proposta para empresa abatedora de aves. [monografia] Joaçaba: Universidade do Oeste de Santa Catarina, 2010.

[09] Imhoff K. Manual de tratamento de águas residuárias. 1ª ed. São Paulo: Edgard Blücher. 1998.

[10] Braile PM, Cavalcanti JEWA. Manual de tratamento e águas residuárias industriais. São Paulo: Cetesb. 1993.

[11] D'Amico RVL. Redes para sustentabilidade: estudos de caso sobre o manejo dos resíduos sólidos no Brasil. [dissertação] São Paulo: Universidade de São Paulo. 2015.

[12] Stewart EA, Haselow DL, Wyse NM. Review of operations and performance data on five water hyacinth based treatment systems in Florida 1987; 279-288.

[13] Chernicharo CAL. Pós-tratamento de efluentes de reatores anaeróbios. 2ª ed. Belo Horizonte: Ed. da UFMG; 2001. [acesso 22 jul. 2016] Disponível em: http://www.saneamentoweb.com.br/site_antigo/web/page38.html.

[14] Pratas J, Favas PJC, Paulo C, Rodrigues N, Prasad MNV. Uranium accumulation by aquatic plants from uranium-cantaminated water in central Portugal. International Journal of Phytoremediation 2012; 14(3):221-234.

[15] Martins APL, Reissmann CB, Favaretto N, Boeger MRT, Oliveira EB. Capacidade da Typhadominguensis na fitorremediação de efluentes de tanques de piscicultura na Bacia do Iraí – Paraná. Revista Brasileira de Engenharia Agrícola e Ambiental 2007; 11(3):324-330.

[16] Harguinteguy CA, Pignata ML, Fernández-Cirelli A. Nickel, lead and zinc accumulation and performance in relation to their use in phytoremediation of macrophytes *Myriophyllum*aquaticum and Egeria densa. Ecological Engineering. 2015; 82:512-516.

[17] Owamah HI, Enaboifo MA, Izinyon OC. Treatment of wastewater from raw rubber processing industry using water lettuce macrophyte pond and the reuse of its effluent as biofertilizer. Agricultural Water Management. 2014; 146:262-269.

[18] Li G, Zai J, He Q, Zhi Y, Xiao H, Rong J. Phytoremediation of levonorgestrel in aquatic environment by hydrophytes. Journal of Environmental Sciences. 2014; 26(9):1869-1873.

[19] Andrade JCM, Tavares Srl, Mahler, CF. Fitorremediação: o uso de plantas na melhoria da qualidade ambiental. 1ª ed. São Paulo: Oficina de Textos. 2007.

[20] Sperling MV. Princípios do tratamento biológico de águas residuárias: introdução à qualidade das águas e ao tratamento de esgotos. 4. ed. Belo Horizonte: Ed. da UFMG. 2014.

[21] International Water Association Publications. Constructed Wetlands for Pollution Control: Processes, Performance, Design and Operation. London, 2000. [acesso 12 set. 2016] Disponível em: https://pt.scribd.com/doc/208541250/Constructed-Wetlands-for-Pollution-Control-Processes-Performance-Design-and-Operation-by-IWA.

[22] Rubio J, Schneider IAH, Ribeiro T, Costa CA, Kallfez CA. Plantasaquáticas: sorventesnaturais. Revista Ciência Hoje. 2004; 35(205):68-71.

[23] Cardoso LR, Martins D, Terra MA. Sensibilidade a herbicidas de acessos de aguapé coletados em reservatórios do Estado de São Paulo. Planta Daninha. 2003; 21: 61 – 67.

[24] Lorenzi H. Plantas daninhas do Brasil: terrestres, aquáticas, parasitas e tóxicas. 4ª ed. Nova Odessa: Instituto Plantarum. 2008.

[25] PottVj, Pott A. Plantas aquáticas do Pantanal. 1 ª ed. Brasília, DF: Embrapa. 2000.

[26] Denículi W, Oliveira RA, Itaborahy CR. Uso de aguapé na redução de sólidos totais de águas residuáriasda suinocultura. Engenharia na Agricultura. 2000; 8(1):38-51.

[27] Pescod MB. Wastewater treatment and use in agriculture: FAO irrigation and drainage, 1992. [acesso 25 jun. 2015] Disponível em: http://www.fao.org/docrep/T0551E/T0551E00.htm.

[28] Dhir B, Sharmila P, Saradhi PP. Potential of aquatic macrophytes for removing contaminants from the environment. CriticalReviews in Environmental Science and Technology. 2009; 39(9):754-781.

[29] França JBA, Teixeira FIR, Ferreira AA, Neto SA. Eficiência das Macrófitas*Eichhornia crassipes* (MART.) SOLMS. (AGUAPÉ) E *Pistiastratiotes l.* (Alface d' água), Cultivadas em diferentes materiais no tratamento de efluente sanitário bruto. Engenharia na Agricultura. 2012; 20(6):554-563.

[30] Reidel A, Damasceno S, Tti DEZ, Sampaio SC, Feiden A. Utilização de efluente de frigorífico, tratado com macrófita aquática, no cultivo de tilápia do Nilo. Revista Brasileira de Engenharia Agrícola e Ambiental. 2005; 9:181-185.

[31] Mees JBR, Damasceno S, Boas MAV, Fazolo A, Sampaio SC.Estabilização da biomassa de aguapé através da compostagem com águas residuárias de suínos e resíduos de frigorífico. Semina: CiênciasAgrárias. 2009; 30(3):709-716.
[32] Verma VK, Singh YP, Rai JPN. Biogas production from plant biomass used for phytoremediation of industrial wastes. Bioresource Technology. 2007; 98(8):1664-1669.
[33] Mishima D, Kuniki M, Soda SS, Lke M, Fujita M. Ethanol production from candidate energy crops: Water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes* L.). Bioresource Technology. 2008; 99(7):2495-2500.
[34] Lasat MM. Phytoextraction of Toxic Metals: a review of Biological Mechanisms. Journal of Environmental Quality. 2002; 31(1):109-120.
[35] Pratas J, Favas PJC, Paulo C, Rodrigues N, Prasad MNV. Uranium accumulation by aquatic plants from uranium-cantaminated water in central Portugal. International Journal of Phytoremediation. 2012; 14(3):221-234.