"Nutrient removal of nitrogen and phosphorus in an artificial wetland subsurface flow under the influence of macrophyte Chrissopogon Zizaniodes".

AUTHOR: HUGO ARANGOITIA VALLADARES & JUAN CARLOS ALARCON

COUNSEL: OTTO ROSASCO GERKES

SUMMARY

efficiency nutrient removal (nitrates and phosphates) for domestic wastewater by tertiary treatment, this research evaluated the proposed treatment system was by Artificial Wetlands Sub Surface Flow (HASS). The research was conducted at the Research Center Wastewater Treatment and Hazardous Waste (CITRAR-UNI), Lima-Peru. two artificial wetlands (H1 and H2), both presented as gravel filter medium 1-2 "inch, like gravel bed support 4" inch was built. And vent pipes. Additionally the wetland macrophytes present ***Chrissopogon Zizanio***des H1. He was investigated for nine months, achieving removal efficiencies of 75% nitrate for hydraulic retention time (HRT) 8 hours and 85% for a HRT of 12 hours.,

KEYWORDS: Water Rsiduales, Nutrient Removal Nitrates, Phosphates, Artificial Wetland; Chrissopogon Zizaniodes

INTRODUCTION

The United Nations (UN) goals set in the Millennium Development Goals (MDGs) in its 7c above objective, Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic services sanitation, however, has not reached the target in terms of sanitation service. between Latin America has only one service coverage of 67%.

Peru makes sanitation programs to reach the proposed member organizations is the UN, WHO coverage. Among some of its policies, the state agency the National Superintendence of Sanitation Services made a diagnosis of treatment plants, municipal water WWTP (Sunass, 2015), noting that some plants wastewater treatment has already exceeded the design stage, in others, there is little or no operation and maintenance due to lack of funds for maintenance of mechanical equipment, resulting in evacuating untreated effluents, altering the ecosystems in the receiving bodies (rivers, lakes and ponds) as in the case of eutrophication excess nutrients.

The problem generated by the presence of nutrients (nitrogen and phosphorus) is eutrophication in receiving bodies, Nitrogen generates negative effects one of them is the reduction and / or absence of dissolved oxygen in water bodies such as lakes, rivers, ponds also toxicity to aquatic life and deficiency of the effectiveness of potential chlorine disinfectant (Diaz et al, 1995)

In Peru, the regulations issued Supreme Decree No. 015-2015-MIMAN, modify the Environmental Quality Standards for Water and establish additional provisions for implementation. This legislation protects the receiving bodies of certain organic, inorganic, microbiological substances that alter water bodies (lakes, ponds, rivers, sea). For Category 3-reuse water for irrigation of plants and animals drink, nitrates should not exceed 90 mg / l. For Category4-dumping lakes rivers, lakes, nitrates should not exceed 13mg / l for total, not more than 0.05 mg / l phosphorus.

The research raises an alternative treatment principle is the biodegradation of organic matter by microorganisms adhered to a substrate and absorption of nutrients by a macrophytes for it, was evaluated in two artificial wetlands in their surface flow (HASS) built to scale pilot.

One of them presented as support gravel bed 4 inches, as a filter medium (substrate) shortlisted gravels (2 ½ inches), the macrophytes research is Chrissopogon Zizaniodes, this macrophyta has been investigated during the last decades in research center considering a option treatment of municipal wastewater and mine tailings, one of its characteristics is the development of roots, rhizomes and stolons can grow up to three meters, allowing greater adherence of minerals and nutrients compared to other macrophytes as Juncus and Phragmites australis (Reed). For the other artificial wetland has the same bed support and substrates, but has no macrophytes (white)

Our proposal is to aerate HASS, by means of ventilation holes through vertical tubes of PVC ½ "inches, distributed evenly spaced along each wetland tubes reach support bed are distributed widthwise of each wetland, the inflow air allows the transfer of oxygen, resulting in low concentrations of dissolved oxygen, allowing present anoxic conditions, this helps in accelerating the processes of nitrification-denitrification, allowing greater absorption of nutrients by macrophytes.

The research was conducted at the research center treatment of wastewater and hazardous waste (CITRAR-UNI) National University of Engineering (Lima, Peru), where municipal wastewater from human settlements Angel and the miracle is captured.

Municipal wastewater go through a screening, a pre-treatment (sand trap) and then to primary treatment, an anaerobic reactor primary upflow sludge blanket (UASB), finally, are carried HASS pilot. The research was carried out for 9 months (January-September 2016) .The evaluated the pH, temperature, relative humidity, nitrates, total phosphorus, BOD5 and COD according to standard methods for Water Analysis and wastewater (APHA). Concluding that the process of nutrient removal by vetiver macrophytes in constructed wetlands with ventilation allows greater efficiency of 72.3% in nutrient removal for a retention time (TR) of 8 hours, and the TR 81.4% for 12 hours and it is inexpensive technology with low operation and maintenance.

The research was made in the gray water treatment proposed by the Educational Institution IE Ramilo Prialé Prialé of San Juan de Lurigancho, Lima, Peru in the school competition of Good Practice for saving water developed by SUNASS, which allowed them to win the competition, obtaining financing will be replicated by that educational institution.

Research contributes to the project bank technology of artificial wetlands CITRAR-UNI, just keep working on this type of technology to be considered in the National Building Code of Peru.

METHODOLOGY

Description of Experimental Area

The experimental project area will be developed in environments Research Center Wastewater Treatment and Hazardous Waste (CRITRAR), belonging to the National Engineering University, Lima-Peru. To do this, two artificial wetlands of subsurface flow (HASS) materials of brick and cement (type face side) of 1,60mx0,40mx0,80m dimensions (length, width and height) was built. Each system has gravel wetland 1-2 "as a filter medium and support as gravel bed 4". Call H-1, the arificial wetland subsurface flow to the unit having macrifita VETIVER, while the Aritificial subsurface flow wetland without macrophyte the call H-2.

Distribution of Ventilation

In artificial wetlands to ensure the same flow entering the two treatment units, composite material PVC valves ½ "inch was installed. Allowing a constant flow of income for H-1 and H-2.
Both artificial wetlands have ventilation pipes, which serve the function of allowing the entry of air flow, allowing you to enter certain amounts of oxygen from the atmosphere to the effluent to be treated. To this end pipes Policloruo material Vinyl (PVC) ½ "inch settled. diameter. Along each HASS. Vent pipes is installed as vetical and reaching the bottom of the filter media bed surface or support in that area said pipes are distributed horizontally across the artificial wetland. The horizontal pipe has holes ¼ "in. in diameter allowing flow exchange effluent treatment with atmospheric oxygen admission. (Figure 01).

Figura 01.-Ventilation Pipe

Figura 02.- Holes in Pipe

Figura 03.-Distribution Pipe

Affluent of Artificial Wetland Flow Sub-surface

The influent wastewater is captured human settlements The Angel and the Miracle AA.HH, as pre-treatment chamber go through a thick gratings, thin camera grills, and a sand trap. After passing through the primary treatment is an anaerobic upflow reactor (UASB).

For our research, tributaries to treat (UASB reactor outlet). They are veritidos to a storage tank of 600 liters capacity by a line drive anaerobic upflow reactor (UASB) to the tank where its only function is to allow the entry of constant flow wetlands through a gravity system.

Sampling points

a point of sampling the entry and exit of each processing unit will be left. The storage tank distributes the same flow in each artificial wetland and being the same tributary sampling input will be one for the two artificial wetlands to be representative. For effluent treatment each unit will have its sampling point. The in situ tests were: pH, influent-effluent temperature, relative humidity; and laboratory analysis were: COD, BOD, nitrates and phosphates. Stage monitoring was conducted during the months of January-September, 2016.
Laboratory tests were developed using standardized methods for analysis of water and wastewater (APHA, 1992)

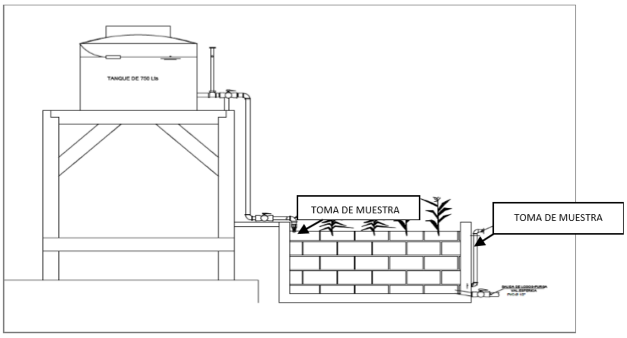

Figura 04.- Schematic and sampling

Filter Media

Gravel as a filter medium 1-2 "inch was used. It is a common material used in the treatment system by artificial wetlands, also because considered material found in quarries loan material allows easy access and availability of such material. Also, considering that the proposal has economic and social scope, it was considered the useful material and low cost.

Figura 05.-Washing of gravel

Figura 06.-Selection of gravel

Macrophyta

Research Center Wastewater Treatment and Hazardous Waste (CRITRAR) presents macrophytes growing area (nursery) between one of his macrophytes is ***Chrissopogon Zizanio***.

For research I was first conditioned at the macrophyte, as these were rooted in natural terrain, for macrophytes of extracted soil and were installed in a nutrient dilutions containers for 10 days. This because the macrophytes and nutrient absorption will form in a medium wastewater and gravel, this conditioning will allow your roots and rhizomes suit the type of support to develop. (Orihuela, 2007). three macrophytes were conditioned, and with a size of 0.20m roots.

Figura 07.-Chrissopogon Zizanio

Figura 08.-Conditioning of the macrophyte

Figura 09.-Selected macrophyte

RESULTS AND DISCUSSION

During the development of research, in situ parameters such as pH, temperature, relative humidity and parameters such as COD, Nitrates, Phosphates in laboratory evaluated CITRAR-UNI

PH, income research was conducted for nine months during the evaluation period the pH to artificial wetlands (E): 7.13 pH prom with range [6.7-7.13]; artificial wetland for H-1: prom pH = 7.40 with range [6.93-8.2] and the artificial wetland H-2: prom pH = 7.53 with range [7.14-8.3]

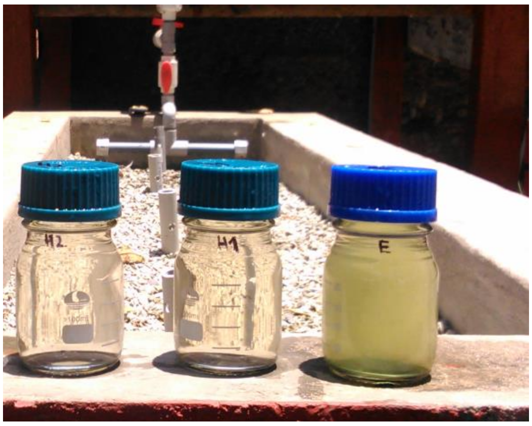

Figura 10.-Samples to analyze

Temperature

The research was conducted for nine months during the evaluation period of the various temperature, since the initiation stage evaluation a climate of caluros-summer (January-March) appeared, in step midseason (Arbril-July) and winter weather (August-September), reaching measure temperature, for entry to artificial wetlands (E): T = 20.27 ° prom with range [17.30-35.10]; for the artificial wetland (H-1): T ° = 19.78 with range [17.10-28.60] and the artificial wetland (H-2): pH = 19.69 with range [17.40-23.00].

Relative Humidity

The research was conducted for nine months during the evaluation period of the various temperature, since the initiation stage evaluation a climate of caluros-summer (January-March) was presented at the stage mid-season (April to July) and winter weather (August-September), reaching measure relative humidity (RH) = 52.48 prom with range [18, 80].

Environmental temperature

The research was conducted for nine months during the evaluation period of the various temperature, since the initiation stage evaluation a climate of caluros-summer (January-March) was presented at the stage mid-season (April to July) and winter weather (August-September), reaching measure Ambient Temperature (TA) prom = 20.84 ° C with range [17, 34.30] ° C.

COD

The research was conducted for nine months, proof of the determination of COD was conducted in the laboratory of CITRAR once a week, the first five months (January-May) was evaluated for hydraulic retention time (HRT) 8 hours, obtained for artificial income (E): COD prom = 181mg / l; for the artificial wetland (H-1): COD prom = 89.38 mg / l, for the artificial wetland (H-2): COD prom = 98.5mg / l. Getting efficiencies for H1 = H2 = 52.90 and 57.41

For the hydraulic retention time (HRT) of 12 hours for the income obtained from artificial (E) = 238.93mg prom COD / l; arficial for wetland (H-1): COD prom = 118.66 mg / l, for the artificial wetland (H-2): COD prom = 119.13mg / l. Getting efficiencies for H1 = H2 = 47.85 and 40.99

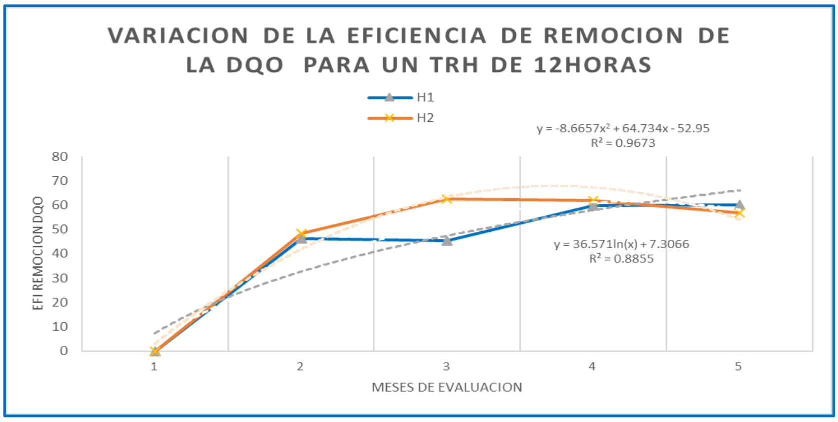

Figura 11.-Efficiency in removal of the COD for a retention time of 12 hours

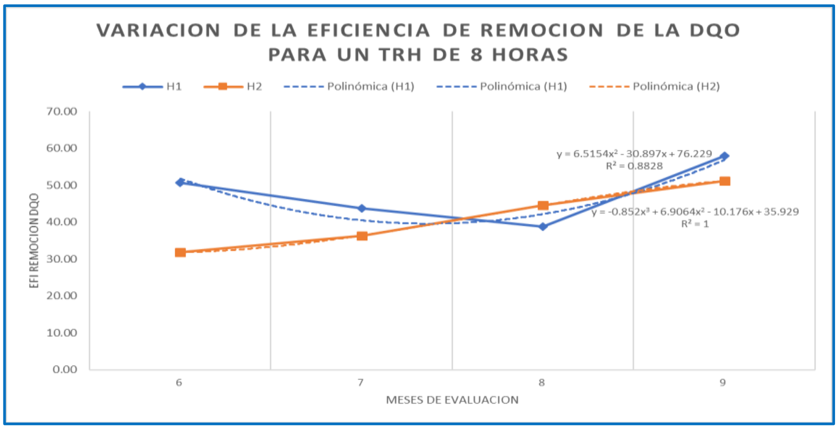

Figura 12.- Efficiency in removal of the COD for a retention time of 8 hours

Nitrate

The research was conducted for nine months, proof of the determination of COD was conducted in the laboratory of CITRAR once a week, the first five months (January-May) was evaluated for hydraulic retention time (HRT) 8 hours, obtained for artificial income (E): NO3- prom = 11.75mg / l; for the artificial wetland (H-1): NO3-prom = 1.40mg / l for the artificial wetland (H-2): NO3- prom = 3.12mg / l. Getting efficiencies for H1 = H2 = 83.65 and 68.77

For the hydraulic retention time (HRT) of 12 hours for the income obtained from artificial (E):): NO3-prom = 16.88mg / l; for the artificial wetland (H-1): NO3-prom = 4.00mg / l for the artificial wetland (H-2): NO3- prom = 3.36mg / l. Getting efficiencies for H1 = H2 = 78.95 and 77.48

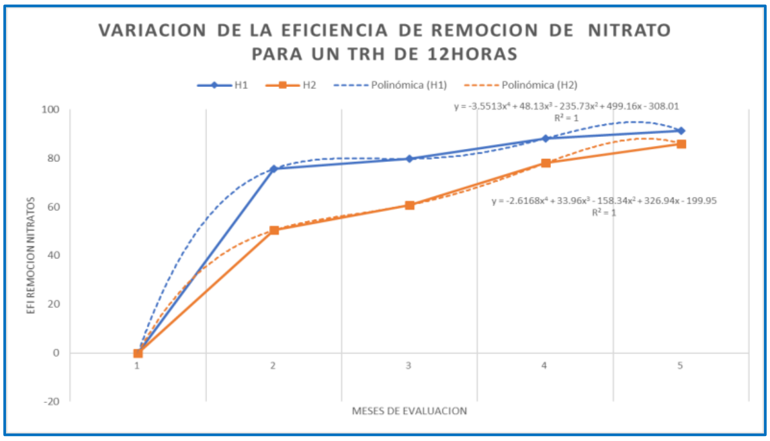

Figura 13.-Efficiency in removal of the Nitrate for a retention time of 12 hours

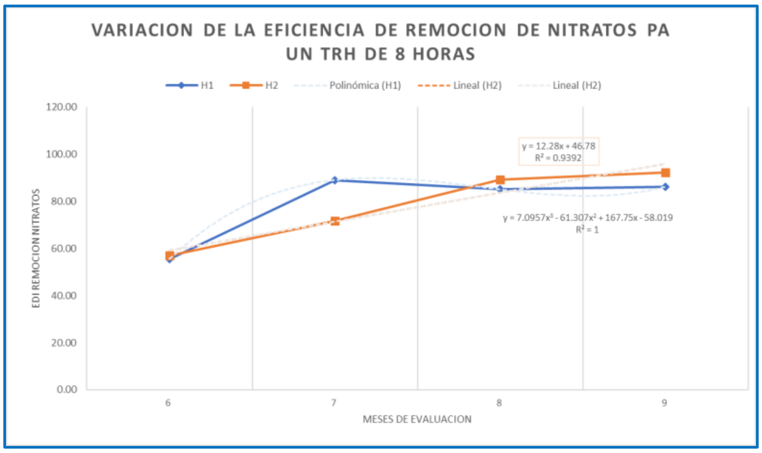

Figura 14.-Efficiency in removal of the Nitrate for a retention time of 8 hours

Phosphate

The research was conducted for nine months, proof of the determination of COD was conducted in the laboratory of CITRAR once a week, the first five months (January-May) was evaluated for hydraulic retention time (HRT) 8 hours, obtained for artificial income (E): PO3- prom = 16.63mg / l; for the artificial wetland (H-1): PO3-prom = 15.17mg / l for the artificial wetland (H-2): PO3- prom = 15.15mg / l. Getting efficiencies for H1 and H2 = = 16.40 13.01

For the hydraulic retention time (HRT) of 12 hours for the income obtained from artificial (E):): PO3-prom = 20.2mg / l; for the artificial wetland (H-1): PO3-prom = 17.65mg / l for the artificial wetland (H-2): PO3- prom = 18mg / l. Getting efficiencies for H1 = H2 = 13.76 and 10.48

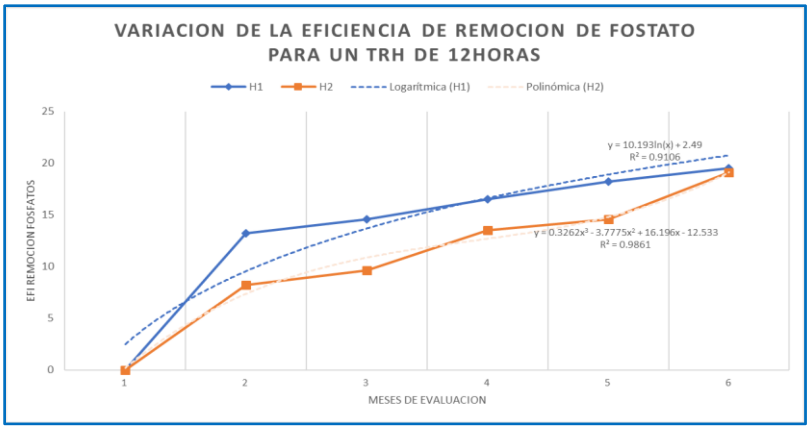

Figura 15.-Efficiency in removal of the Phosphate for a retention time of 12 hours

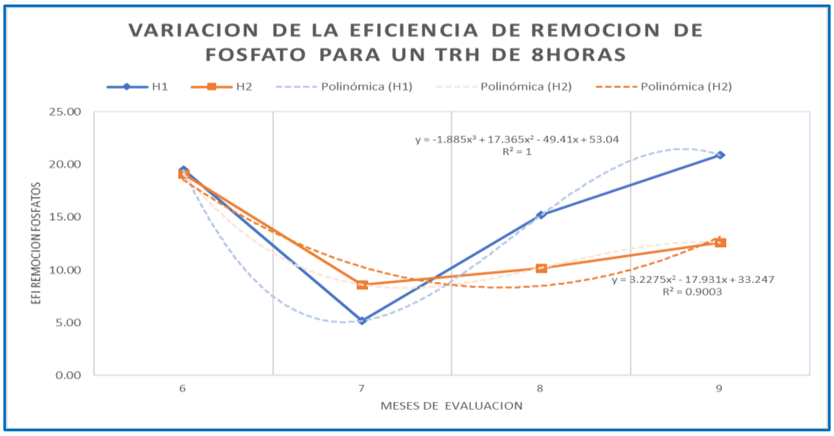

Figura 16.- Efficiency in removal of the Phosphate for a retention time of 8 hours

Anexo:

The treatment system was proposed as a proposal for the SUNASS Good Practice Contest, winning the proposal and being financing to be replicated in EI. Ramiro Priale Priale

Figura 17.-Working group presenting the proposal for the competition "Good Practices -SUNASS", Educational Institution Ramiro Priale Priale

CONCLUSIONS

1.The system of tertiary treatment by artificial wetlands influence of macrophyte Chrissopogon Zizaniodes allows more efficient removal of nutrients such as nitrates, however, Phosphates efficiency is negligible.

2.Se shows that for older hydraulic retention times, increases the efficiency of nitrate removal. Research for hydraulic retention time of 12 hours the nitrate removal efficiency is higher compared to the hydraulic retention time of 8 hours.

3.The Environmental conditions (summer weather) allows higher ambient temperature, higher radiation for the development of macrophytes. However cold weather (winter) the nutrient removal efficiency is lower.

4.The results in removal of nitrates are below the demands of the Peruvian law. This favors the HASS considered as an alternative treatment of nutrients (nitrates).

5.La research was made in the gray water treatment proposed by the Educational Institution IE Ramilo Prialé Prialé of San Juan de Lurigancho, Lima, Peru in the school competition of Good Practice for saving water developed by SUNASS.

6. The operation and maintenance of artificial wetlands minimum, our project for cleaning the pipes that distribute the influent once a week was made because the distribution holes clogged by suspended particles that brings the tributary.

7. The tank that supplies wetlands should only be used as tank step to properly distribute the flow. The tank for the project only stored 600 liters were treated during the day. Every day was done pumping into the tank, this to prevent the tank operates as a settler.

8.Se requires further investigate the treatment system of artificial wetlands influence of macrophyte Vetiver, as the results were positive, evaluate the maximum capacity of absorption of nutrients.

9.Evaluar the hydraulic behavior, the type of flow that is developed in artificial wetlands.

10. It is recommended to evaluate the size of roots of the macrophytes, as the literature mentions that its roots at the end of 8 months may grow up to 1.50m

11.Seguir evaluating other materials used as bed sutrato and support within the artificial wetlands

12.Evaluar dissolved oxygen that can enter through the vent pipes, for controlling the dissolved ocigeno will favor the conditions for nitricación-desnitricación processes.

BIBLIOGRAPHY

METCALF & EDDY

1996 *Ingeniería de las Aguas Residuales Tratamiento,vertido y reuso.Volumen 1.Antonio Garcia Brage.3ra Edición.España.McGRAW-HILL.*

SOANEZ CALVO, Mariano

1999 *Aguas Residuales:Tratamiento por Humedales Artificiales.1ra Edición.Madrid.Mundi-Prensa.*

VON MÜNCH, Elizabeth

2009 *Humedales Artificiales para el tratamiento de aguas grises y aguas residuales domesticas en países en desarrollo.Primera edición.Agencia de la Cooperación Técnica Alemana (GTZ).diciembre 2009.*

< http://www.gtz.de/en/themen/umweltinfrastruktur/wasser/9397.htm >

MINISTERIO DEL AMBIENTE

2008 *De Decreto Supremo Nº002-2008-MINAM.Estandares de Calidad Ambiental (ECA) para agua,Categoria III y IV.31 de julio.*

MINISTERIO DEL AMBIENTE

2010 *Decreto Supremo Nº003-2010-MINAM.Limites Maximos Permisibles (LMP) para efluentes de PTAR.17 marzo.*

MINISTERIO DEL AMBIENTE

2015 *Decreto Supremo Nº015-2015-MINAM.ESTANDARES DE CALIDAD AMBIENTAL (ECA-AGUA)-Categoria 3,4*

MINISTERIO DE VIVIENDA, CONSTRUCCION Y SANEAMIENTO

2015 *Decreto Supremo Nº001-2015-Vivienda-Modifican Valores Maximos Admisibles(VMA) de las descargas de aguas residuales no domesticas en el sistema de alcantarillado sanitario. 10 de enero.*

KAMAU,C

2009 *Constructed wetlands: potencial for their use in tratament of grey wáter in Kenya.Msc Thesis-Alberchts University,Kiel.Germany.*

< http://www2.gtz.de/Dokumente/oe44/ecosan/en-constructedwetlands-potential-for-use-2009.pdf >

DIAZ Y SANTOS

1995 *Tratamiento Biologico de las Aguas Residuale.Pag 89-171.*

PEÑA OROCAJA, Daniel & INFANTES Flores Rafael

2012 *Evaluación de la eficiencia de recomocion de un humedal arfiticial en función de la grenuñometría de grava en el medio filtrante.Tesis para optar Título profesional de Ingenieria Sanitaria.Lima,2012*

MALDONADO YACTAYO,Vitor Antonio

2005 *Uso de wetlands para el tratamiento de reuso de aguas residuales domesticas.Tesis para optar Título Maestro en Ciencias con mencion en Tratamiento de guas y reuso de desechos.Lima,2005.*

GOICOCHEA ARÉVALO ,Diego Salvador

2014 *Influencia de los Materiales Filtrantes, PVC corrugado y Grava, en la Remoción de Materia Orgánica, en Humedales Artificiale.Lima,2014*

Oscar Delgadillo-Alan Camacho-LuisF. Perez-Mauricio Andrade

201 *Depuracion de aguas residuales por medio de humedales artificiales-Centro Andino para la Gestion y Uso del Agua(Centro Agua,Cochabamba-Bolivia).*

GONZALES,Maribel-SALDARRIAGA,Julio Cesar

2008 *Remoción Biológica de materia orgánica ,Nitrigeno y Fosforo en un sistema tipo Anaerobio-anoxico-aerobio,Escuela de Ingenieria de Antioquia,Medellin-Colombia.*

AGENCIA DE LA COPERACION TECNICA ALEMANA(GTZ)

2008 *FAQs Constructed wetlands.A Sustainable Option for Wastewater Treatment in the Philippines,GTZ-Philippines and Bayawan City*

< http://www2.gtz.de/Dokumente/oe44/ecosan/en-FAQsconstructed-wetlands-2008.pdf >

APHA

1992 *Métodos normalizados para el análisis de aguas potables y residuales(APHA,1992)*

NACIONES UNIDAS

2015 *Objetivos de Desarrollo del Milenio Informe 2015.Nueva York*

<http://www.un.org/es/millenniumgoals/pdf/2015/mdg-report-2015_spanish.pdf>

SUPERINTENDENCIA NACIONAL DE AGUA Y SANEAMIENTO

2015 *Diagnóstico de las Plantas de Tratamiento de Aguas Residuales en el Ambito de Operación de las Entidades Prestadoras de Servicio Saneamiento*

http://www.sunass.gob.pe/doc/Publicaciones/ptar.pdf