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REMOVAL OF HUMIC SUBSTANCES THROUGH THE OXIDATION WITH OZONE AND HYDROGEN PEROXIDE AND SLOW FILTRATION

REMOÇÃO DE COR EM COLUNAS DE CARVÃO ATIVADO GRANULAR COMO POLIMENTO DE EFLUENTE DE INSTALAÇÃO FIME, EM FUNÇÃO DA TAXA DE APLICAÇÃO

The presence of humic substances in the water of supply has received attention of several researchers in the last decades, because it can generate by-products when exposed to oxidants and disinfectants. The multistage filtration (FiME) is an alternative considered to achieve water treatment for small size rural communities, however, the efficiency with relationship to the removal of true color associated to dissolved organic carbon or to humic substances, has been questioned or reported as low. Slow filtration with pre-ozonation is being used, since the ozone acted in the molecules of the organic matter of high molecular weight, increasing its biodegradability and by-products disappear soon after the application. The combined application of ozone and hydrogen peroxide has the objective of producing species with free radicals, of short-lived, that are highly reagents and can oxidize most of the present substances in the natural water. The present research evaluated the removal of humic substances in slow sand filtration, using for that evaluation indirect parameters as true color, absorbance 254 nm and dissolved organic carbon. Five experiments were realized using four slow filters, being two with layer of granulate activated carbon (GAC), in that several pre-oxidation alternatives were rehearsed with ozone and hydrogen peroxide. It was obtained, as main conclusion that the slow filters with GAC proceeded of oxidation with ozone and hydrogen peroxide, in appropriate doses, presented medium removal of true color of 64% of the initial color. It was also concludes that the hydrogen peroxide interferes in the development of the biological layer, interfering in the development of the loss of head, in the turbidity removal and in the removal of humic substances

PERFORMANCE EVALUATION OF A SEDIMENTATION UNIT: HYDRAULIC PARAMETERS AND THEIR INFLUENCE SEDIMENT WATER QUALITY

AVALIAÇÃO DE DESEMPENHO DE UMA UNIDADE DE DECANTAÇÃO CONVENCIONAL: LEVANTAMENTO DOS PARÂMETROS HIDRÁULICOS E SUA INFLUÊNCIA NA QUALIDADE DA ÁGUA DECANTADA

Based on a case study, the importance of a constant assessment of water treatment processes is emphasized, with particular attention to sedimentation. The survey of the hydrodynamic characteristics of the sedimentation basin and the systematization of a large data base of water quality monitoring, allowed the confirmation of beneficial effects from interventions carried out during the period of this study: procedures of sludge removal and the sedimentation basin's leveling. Microbiologic characterization of filter backwash water and assessment of some recycling scenarios. The objective of the study was to characterize filter backwash water considering the turbidity and microorganisms (*Escherichia coli*, *Bacillus subtilis*, *Clostridium perfringens*, *Giardia* spp. e *Cryptosporidium* spp.) and to analyze some possible recycling scenarios as a way of planning this

operation with views to minimize health risks. Regarding the parameters analyzed in the clarification process, the best results were obtained when cationic polymer was used in comparison with other situations. The presence of resistant organisms in filter backwash water, even after clarification process, indicates the need of greater attention when considering recycling situation in water treatment plants. The results suggest that the clarification contributes to reduce the risks associated to filter backwash recycling. The best results found in the clarification processes suggest the use of the cationic polymer resulting in considerable reduction of organisms and consequent reduction of associated risks.

INITIAL EFFICIENCY COLLECTOR MODELS FOR THE UP FLOW FILTRATION IN A SATURATED POROUS MEDIA

MODELOS DE CÁLCULO DA EFICIÊNCIA INICIAL DO COLETOR PARA FLUXO
ASCENDENTE NA FILTRAÇÃO EM MEIOS POROSOS SATURADOS

The use of a mathematical model allows to obtain conditions for the prediction, operation and control the filtration process, which drives to the improvement of the process in a saturated porous media. The mathematical models describe the filtration process through the mechanisms of particles removal which take place in the medium filter. This work proposes the mathematical modeling based on the models for initial efficiency collector for up flow filtration in a saturated porous media. The existing models for the determination of the initial efficiency collector were conceived for down flow filtration and this work proposes its adaptation for the application to the up flow direct filtration in granular sand material. It takes into account the contribution of the gravitational factor in the efficiency portion for gravity settling in the proposed models for the initial efficiency collector. For the conception proposal in this work, a bench scale setup was utilized for the up flow direct filtration experiments besides the use of computational tools for mathematical regression. For a comparative analysis and validation of the models proposed for up flow filtration values of existing models for initial efficiency collector (conceived for down flow) were used, as well as values obtained by experimental pilot plant for up flow direct filtration.

COMPARATIVE STUDY OF COLORED WATER SAMPLES MADE UP OF DIFFERENT HUMIC SUBSTANCES WITH DIFFERENT PROPERTIES

ESTUDO COMPARATIVO DE REMOÇÃO DE COR DE ÁGUAS PREPARADAS
COM SUBSTÂNCIAS HÚMICAS DE DIFERENTES CARACTERÍSTICAS

The influence of the different characteristics of humic substances present in water with was studied in this work in order to observe the treatment performance by coagulation, flocculation and sedimentation. It was verified that the different molecular weights of the humic substances used to provide the same color (100 HU) in the samples of study waters influenced very much the efficiency of color removal. The removal of apparent color resulted higher for the water study

prepared with the fraction of humic substances with biggest molecular weight (> 100 KDa). When comparing the results of color removal with those of nuclear magnetic resonance and infrared ray, it was observed that the higher the number of groups with the presence of the oxygen in the humic substances, the smaller was the efficiency of color removal for the same conditions of coagulation, flocculation and sedimentation.

THE COAGULATION EFFECT USING ALTERNATIVE PRE-OXIDANTS TO THE CHLORINE IN THE FORMATION POTENTIAL OF ORGÂNIC HALOGENATED BYPRODUCTS IN WATER WITH HUMIC SUBSTANCES

O EFEITO DA COAGULAÇÃO COM O USO DE PRÉ-OXIDANTES ALTERNATIVOS AO CLORO NO POTENCIAL DE FORMAÇÃO DE SUBPRODUTOS ORGÂNICOS HALOGENADOS EM ÁGUA CONTENDO DE SUBSTÂNCIAS HÚMICAS

The presence of humic substances in water supply has brought many problems, resulting from the formation of halogenated organic byproducts, which are expected to be carcinogenic, especially when pre-oxidation with chlorine is adopted. The main halogenated organic compounds that can be found in treated water, are trihalomethanes, haloacetic acids, haloaldehyde, haloacetones, halophenols, and halopicrin. The use of pre-oxidation with chlorine contributes for the formation of such byproducts in water treatment plants (WTP). This research was carried out to evaluate the potential formation of the following substances: trihalomethanes, haloacetic acids, haloaldehydes, haloacetones, halophenols, halopicrins and chloral hydrate by gas chromatography with electron capture detector in a water prepared with addition of humic substances extracted from peat soil, pre-oxidated with chlorine, chlorine dioxide, potassium permanganate, hydrogen peroxide, ozone and peroxone, followed by coagulation, filtration, and post-chlorination. The results obtained showed that the use of alternative pre-oxidants, such as: potassium permanganate, chlorine dioxide, hydrogen peroxide, ozone and peroxone, associated with coagulation, filtration, and post-chlorination produce significant amounts of byproducts, with attention for the substances not cited in the current legislation.

SELECTION OF WATER TREATMENT TECHNOLOGIES AS FUNCTION OF THE TREATMENT PROCESS, UTILIZATION AND DISPOSAL OF THE WASTES GENERATED IN THE WTPS

SELEÇÃO DE TECNOLOGIAS DE TRATAMENTO DE ÁGUA EM FUNÇÃO DO TRATAMENTO, APROVEITAMENTO E DISPOSIÇÃO DOS RESÍDUOS GERADOS NAS ETAS

This article presents the conceptual model of the selection of surface water treatment techniques involving treatment, utilization and removal of the wastes generated in the water treatment plants (WTPs) with flow rates between 10 L/s and 100 L/s. The model benefits small – and medium – sized Brazilian communities.

The development of the model required the study of several factors that allowed defining the variables and indicators of selection, which formed the conceptual selection model (CSM) with

seven sublevels, which are interconnected. The model progressively selects the water treatment plans with higher sustainability likelihood, according to the input data (F), criteria (A), procedures (B) and selections (S) established in its development.

It was possible to conclude that the applicability of CSM is restricted to the WTPs that meet all the domain requirements established. However they do not eliminate the design engineer from evaluating other techniques of treatment, utilization and disposal of the wastes which are not take into account by this model. It was also concluded that the selection of the technology for treatment, utilization and disposal of the wastes should not be evaluated independently of the one selected in the WTPs.

REMOVAL OF CYANOBACTERIA IN THE TREATMENT OF WATER FROM DAMS SUBMITTED TO EUTROPHICATION, BY MEANS OF DOUBLE FILTRATION AND OXIDATION

REMOÇÃO DE CIANOBACTÉRIAS NO TRATAMENTO DE ÁGUA EUTROFIZADA
UTILIZANDO DUPLA FILTRAÇÃO E OXIDAÇÃO

The objective of this work was to evaluate the cyanobacteria cells removal in the treatment of raw water stored in dams submitted to eutrophication processes, through double filtration, using Poly Aluminum Chloride and cationic polymer as coagulants, and oxidation with chlorine, chlorine dioxide and potassium permanganate. A pilot installation formed by 4 pairs of filters, simultaneously operated was used. The filtration runs were carried out using equal dosages of coagulants. To evaluate the effect of the oxidants, the first pair of filters did not receive oxidant, in the second pair was applied a dosage of 2,0 mg/L of chlorine, the third received a dosage of 1,0mg/L of chlorine dioxide and the last one was operated with a dosage of 0,25mg/L of potassium permanganate. The oxidants were applied either before the upflow filters or between the filters. The results showed that a cyanobacteria cells removal above 99.9% could be achieved through double filtration treatment. The use of chlorine and chlorine dioxide increased the removal of cyanobacteria cells. No advantages of algal cells removal was observed by the application of potassium permanganate, probably due to insufficient dosages.

INTEGRATING A PREDICTIVE WATER CONSUMPTION MODEL TO A REAL TIME MODEL FOR THE OPERATION OF DRINKING WATER SYSTEMS

INTEGRAÇÃO DE UM MODELO DE PREVISÃO DE DEMANDA DE ÁGUA A UM MODELO SIMULADOR
EM TEMPO REAL NA OPERAÇÃO DE SISTEMAS DE ABASTECIMENTO

Integration between hydraulics simulation and water demand forecast models for planning real time operation, with 24 hours of antecedence, of the metropolitan water mains system of São Paulo is described. Operational programming for short term (real time) is also useful for special events (longer periods).

Daily programming of operation is implanted by a SCADA system, that is responsible for telemetric startup of pumps and changes in position of control valves, to control flows that supply distribution tanks.

This integration created a decision support system, composed by: mathematical models, computational systems, data bases and a friendly interface.

Methodology consists of construction and integration among several models to create a dynamic solution to each specific operational condition.

Proposed methodology may be applied to any system with installed field automation for real time control. The success of this methodology is demonstrated by an application to a great and complex water main system. Improvements of the real time operation conditions results in several advantages: increase the security, reduction of energy costs, better efficiency of hydraulic a mechanical components, reduction in control valves maneuvers, more stable water treatment conditions. The proposed model of operation does not try to reach optimal solutions, but results in excellent and practical operations rules. However it is recommended and it is being prepared for introduction of a real time optimization model as the next step.

ROLE OF THE MICROORGANISMS IN THE CHEMICAL SPECIATION OF ARSENIC: ANALYSIS OF SEDIMENTS OF CAMARONES RIVER, I REGION. CHILE

ROL DE LOS MICROORGANISMOS EN LA ESPECIACIÓN QUÍMICA DEL ARSÉNICO: ANÁLISIS
DE SEDIMENTOS DEL RÍO CAMARONES, I REGIÓN. CHILE

The biogeochemical cycle of arsenic depends on microbial transformation, which affects the mobility and distribution of arsenic species in the environment, and might influence in the toxicity of arsenic.

The aim was to study the microbial redox transformations of arsenic in Camarones river sediments. The biological transformation of arsenic was observed in column experiments. The detection of As (III) and As (V) was carried out for HPLC/HG/QAAS. Identification of the isolates was achieved by RapID (REMEL. INC). A qualitative KMnO₄ method was used to investigate redox activity. The arsenic tolerance was carried out by serial dilution on agar plate. The *arsC* genes were detected by PCR. The sediments induced with arsenite showed a light decrease of As (III) concentration. On the other hand, when they were induced with arsenate there was a significant transformation of As(V) to As(III). 49 bacterial strains were isolated whose tolerance levels varied among <10 and 20 mM for As (III) and among 50 and 1000 mM for As (V). Of these, the highest percentage corresponded to the reducing bacteria (55%), 4% to oxidizer bacteria, 8% presented both activities and in 33% of the bacteria none activity was detected. The *arsC* gene was detected in 9 strains. In the sediment samples exists, a biological activity responsible for the arsenic transformation, this activity would be given mainly by heterotrophic arsenate reducing bacteria and in smaller proportion for arsenite oxidizing bacteria.

BACTERIOLOGICAL STUDY OF WATER SAMPLES ASSOCIATED WITH DIARRHEA OUTBREAKS IN COSTA RICA, 1999-2005

ESTUDIO BACTERIOLÓGICO DEL AGUA ASOCIADO A BROTES DE
DIARREA EN COSTA RICA, 1999-2005

This article provides the results of the bacteriological study in water samples coming from aqueducts of communities in Costa Rica associated with diarrhea outbreaks between 1999 and 2005. The procedure followed in Costa Rica for facing this type of emergencies is described in the article, as well as the role of the Water National Laboratory of Instituto Costarricense de Acueductos y Alcantarillados (LNA), as part of the national net of laboratories for attending diarrheas and cholera diseases. In this case, the aim of the laboratory is to carry out a sanitary inspection in all the affected communities, testing water samples for isolating and identification of potentially pathogen bacteria and considered responsible of those waterborne outbreaks. During this events, the bacterial genus commonly isolated in water samples were the following: *Escherichia coli*, *Salmonella* spp, *Shigella* sp., *Enterobacter* sp, *Citrobacter* sp, *Serratia* sp, *Providencia* sp, *Proteus* sp., *Klebsiella* sp, *Aeromonas hydrophila* y *Pseudomonas* spp. Due to the great diversity of circumstances found on those studies, related to a diagnostic that allows establishing water role as transmission instrument of the etiological agent in diarrhea outbreaks, for classifying each circumstance it is proposed the "Qualitative System for Valuation the level of Importance of drinking water in the Transmission of Diarrheas. This system has several categories, the first one defines the responsibility of water as a mean of transmission in a diarrhea outbreak compared with the bacteriological results obtained and reported for the laboratories of the Costa Rican health system, until reach the category which excludes water when its quality is proved by bacteriological test. It is worth to mention that in some of the analyzed cases the bacteriological studies were applied to water samples but there were not applied to patients samples; in other cases the etiological agent was isolated in water samples, in these cases there were not found termotolerantes coliforms, indicators of microbiological quality. The opportune intervention of LNA in attending those diarrhea outbreaks promoted an efficient decision making for applying corrective actions regards as water supply for controlling waterborne outbreaks.

TUBULAR SOLAR DISTILLATION: AN OPTION TO OBTAIN DRINKING WATER FROM SALINE WATERS TO SUPPLY RURAL COMMUNITIES

DESTILACIÓN SOLAR TUBULAR UNA OPCIÓN PARA OBTENER AGUA POTABLE
A PARTIR DE AGUAS SALOBRES PARA COMUNIDADES RURALES

This study presents the development of two systems of tubular solar still based in works made by the University of California in the United States in the 50's, and by Japanese investigators in 2003 (Teruyuki et. al.). These distillers were evaluated and compared with the efficiencies obtained in the work of Teruyuki, to determinate, if these prototypes produce enough drinking water for supply five members of a family (2 liters per person per day, It is the minimum requirements for ingestion) which lives in rural areas with problems of brackish water. The objective of the present work was to design a solar desalination system of easy construction, installation, operation and

little maintenance for rural communities (family level). The goal of these distillers is to obtain 10 liters of drinking water per day and it is for 5 members of one family. The evaluated reactors were: a modified tubular solar still (TSS), a concentrator parabolic compound (CPC) mounted in a TSS and a conventional stairway still (CSS). The material of the body of the TSS was of acrylic of 6 inch of diameter and one meter of length, the trough of the TSS and the stairs of the conventional distiller were cover with epoxy black paint of food type degree. The units of this system were: storage tank (450 L), solar heater (for preheated purposes) and the three distillers (TSS, CPC and CSS) which worked at the same time. In the storage tank was prepared an artificial solution of salt, sea salt was used in concentration of 5 to 12 g/L diluted with tap water. The distillers operated during 121 days; the preheated water was distributed in the 3 reactors at the same time. The measured parameters were: conductivity, % of salinity, total dissolved solids (TDS), pH, volume of distilled (fresh water), volume of brine and solar intensity. After 60 days of operation volatile organic compounds were analyzed.

The results showed that the best production in liters per day was the CSS, however the maximum production by occupied area per day was obtained with the DTS 5.6 L/m² d with preheating, and without preheating the production was reduced to 2.96 L/m² d. The arithmetic mode production for the DTS with preheating was of 1.79 L/m² d and 0.44 L/m² d for the CSS. It indicates that is necessary to build 36 DTS and there required 5.6 m² of area or 29 conventional stairway still with 24.36 m² occupied area. The construction and installation cost of each type of distiller would be of 3,507 USD for the DTS and 7,482 USD for the CSS, included the preheated, hydraulic installation, and the distillers (DTS or CSS respectability). In both case, the cost is very high for rural communities, for what other materials must be studied to build the distillers. Also volatile compounds in the fresh water were evaluated after 60 days of operation and it was found chloroform and Toluene at concentrations over the European Union norms for what it is necessary to monitor the water quality of the fresh water, once selected the materials for building them.

EFFECTS OF COMPONENTS OF MULTIPLES EMULSIONS SYSTEM IN THE MTBE CONTAMINANTES BY MICROBIAL CONSORTIUM

EFFECTO DE COMPONENTES DEL SISTEMA DE EMULSIONES MÚLTIPLES EN EL CONSUMO DEL CONTAMINANTE MTBE POR UN CONSORCIO MICROBIANO

The use of water-in-oil-in-water (W1/O/W2) emulsions has been proposed in environmental studies for treating water systems polluted with contaminants in low concentrations, where other treating techniques are not effective. For example it has been proposed that a microbial consortium capable of degrading methyl tert-butyl ether (MTBE) be entrapped in a W1/O/W2 emulsion for treating water contaminated with MTBE. However a proper selection of the materials (emulsifying agents, oil phase) making up the W1/O/W2 emulsion must be carried out in order to ensure that the microbial consortium does not consume these materials, interfering with the degradation of MTBE. The objective of this study was to determine the consumption of potential materials for making up the W1/O/W2 multiple emulsions, in the presence and absence of MTBE, by the microbial consortium. Potential materials proposed for making up the multiple emulsions W1/O/W2 are Span 80 as the primary lipophilic emulsifier, mesquite gum (*Prosopis laevigata*) and

polyacrylic acid as the secondary hydrophilic emulsifiers, and light mineral oil as the intermediate oil phase. Each of these compounds was used by separate at a concentration of 0.2 % in microcosms with and without MTBE. Production of CO₂ was quantified as a measure of the compounds consumption. In the absence of MTBE, results indicate that Span 80 was used as carbon source by the microbial consortium, showing significantly higher ($P < 0.05$) production of CO₂ than that observed for mesquite gum and mineral oil. CO₂ production was non-significantly ($P > 0.05$) different when MTBE was present with Span 80 than when it was not, but was significantly higher ($P < 0.05$) CO₂ production when it was incorporated to mesquite gum or polyacrylic acid than when it was not. Thus, the use of Span 80 in the formulation of W1/O/W2 multiple emulsions entrapping a microbial consortium for degrading MTBE is not recommended, as Span 80 is consumed by the microbial consortium, and it inhibits the consumption of MTBE.

THE EVALUATION OF EXISTING UNITS AS A START POINT FOR OPTIMIZATION OF WATER TREATMENT PLANT ENLARGEMENT: A REAL CASE

LA EVALUACIÓN DE INSTALACIONES EXISTENTES COMO BASE PARA LA OPTIMIZACIÓN DE PROYECTOS DE AMPLIACIÓN DE INFRAESTRUCTURAS DE POTABILIZACIÓN DE AGUAS: UN CASO PRÁCTICO

Water supply for Montevideo, the main city in Uruguay, is provided from the Aguas Corrientes treatment plant which is located 60 km from downtown. In this plant, one of the potabilization systems called "Planta Vieja" has two mechanical flocculation systems, each one provided with seven cells. The flocculation in each cell is made by vertical mixers generating axial flow. At the moment, these units treat a peak flow of 14.000 m³/h with a detention time of 30 minutes. This paper tries to determine the maximum flow that this flocculation systems can admit, based on two items: hydraulic capacity and efficiency of flocculation process for flows up to 22.000 m³/h

DETERMINATION OF THE OPTIMUM DESIGN PARAMETERS FOR A 10.000 M³/H DECLINING RATE FILTRATION PLANT BY USING A PILOT FILTERS PLANT

DETERMINACIÓN DE LOS PARÁMETROS DE DISEÑO DE UNA BATERÍA DE FILTRACIÓN DE TASA DECLINANTE, PARA UN CAUDAL DE 10.000 M³/H, MEDIANTE ESTUDIOS REALIZADOS EN PLANTA DE FILTROS PILOTO

Filtration units for potabilization of surface water should be designed with special attention in three parameters: filtration rate, thickness of the filtration bed and size of the granular media. The size of the filtration plant, and therefore the cost of construction, is basically determined by the first two parameters listed above. Depending on the water quality, the filtration rate could be between 10 to 20 m³/m²/h, and the determination of this parameter is essential for a proper design of large plants. Nowadays, any rational design of filtration units should be based on the results of a pilot plant as a way to determine the design parameters. An inadequate selection would lead to serious problems

in filter operation or to an unnecessary expensive plant. The cost of a pilot plant is always lower than the higher cost that would bring a selection of a very low rate.

This paper shows how to determine the design rate, thickness of the bed filter and type of the granular media for a declining rate filtration unit to be constructed at the the Aguas Corrientes treatment plant. This new plant will increase in 10.000 m³/h the filtration capacity of the Aguas Corrientes treatment plant, which supplies the city of Montevideo with potable water.