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SUMMARY OF DOCTORAL THESIS

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Title: **Study on multi-soil-layering system in relation to structural influence on wastewater treatment efficiency and decolorization of livestock wastewater**

多段土壌層法における汚水処理効率への装置構造の影響と畜産廃水の色除去に関する研究

As a part of MSL system research, this study mainly includes 4 parts: In the first part, the efficiency of MSL system in relation to structure difference was researched. It was found that at HLR of 1000-2000 L m^{-2} day^{-1}, systems with larger SMB surface area had higher removal rates for SS, BOD_5, COD and T-P due to the enhanced contact efficiency between wastewater and SMB. The structure difference was biggest at HLR of 2000 L m^{-2} day^{-1}, especially for COD and T-P removal. When HLR increased into 3000 L m^{-2} d^{-1}, the effect of structure difference on MSL systems became smaller probably because of preferential water flow into PL as well as ORP change caused by accumulation of SS at high HLR. For T-N removal, no structure difference was found at low HLR of 1000 L m^{-2} d^{-1} and when HLR increased to more than 2000 L m^{-2} d^{-1}, secondary effect of SS accumulation and ORP change seemed to influence the systems performance more than the expansion of SMB surface area did.

In the second part, soil's decolorization capacity for wastewater treatment, three types of soil (an Andisol, a sandy soil and a red soil) were compared with activated carbon and charcoal in their respective adsorption and recovery capacities. Sandy soil and red soil showed negative decolorization rates for sewage plant effluent. When 10 g of Andisol was applied to decolorize 30 ml of sewage plant effluent or livestock wastewater diluted 5 times and 20 times, its decolorization rates reached 51.8%, 59.9% and 66.6%, respectively. The decolorization capacity of activated carbon and charcoal varied greatly due to their different original sources and production processes. An analysis of pore size distribution of activated carbons and charcoal showed that their decolorization capacity was in positive relation with their respective outside pore surface area and total meso- pore volume. The result of a recovery experiment showed that activated carbon had a quick desorption for the adsorbed colored substances, which was hardly influenced when incubation time was increased from 7 days to 14 days. While the recovery rates for Andisol, zeolite and charcoal could be enhanced by increasing incubation time from 7 days to 14 days or by decreasing the concentration of colored substances. Under suitable hydraulic loading rate and colored substances concentration, soil-based systems showed sustainable decolorization capacity. A continuous operation of Andisol-based decolorization system, a column (100 cm^3) filled with Andisol (84 g) and activated carbon (6 g) maintained a decolorization rate of more than 60% for 20 days for 20-times

diluted livestock wastewater with an absorbance of 0.8 at a wavelength of 406 nm at a hydraulic loading rate (HLR) of 50 ml soil-100cm^{-3} day^{-1}.

In the third part, four MSL systems with different soil mixture block (SMB) compositions were constructed in four 50 x 10 x 68 cm^3 acrylic boxes. Ten times diluted livestock wastewater with an absorbance of 0.9215 at wavelength of 406 nm and COD concentration around 3000 mg L^{-1} was applied to the systems at a hydraulic loading rate (HLR) of 250 L m^{-2} day^{-1}. Aeration pipes were set in the water permeable layers (PL) in MSL 1-3 and in SMB layers in MSL 4. The results showed that MSL systems could keep mean decolorization rates of 60.7-67.1% and COD removal rates of 48.8-58.0% for 6 weeks' operation. The different aeration pipe positions didn't have any significant influence on the removal efficiency of the systems. However, an increase of aeration intensity from 1000 to 2000 L min^{-1} $system^{-1}$ (27.4-54.8 L min^{-1} L^{-1}) increased decolorization rates by 3.0-12.1%. For COD removal, both the increase of aeration intensity and temperature enhanced the removal rates by 23.0-43.3%. The addition of sawdust and iron in SMB of MSL 1 improved the systems' decolorization rate by 9.1% and COD removal rate by 12.0% compared with MSL 2 during the 5^{th}-6^{th} month operation. Interruption of MSL systems for one month could recover the decolorization and COD removal rates to over 50% and 80%, respectively.

In the last part, further study was concentrated on the pretreatment of livestock wastewater by UV irradiation method. It showed no effect on CODcr and colored substances reduction for livestock wastewater treatment, but it helped in cutting larger molecules (>1000 KDa) into smaller ones (50-1000 KDa). It was suggested that the addition of hydrogen peroxide is necessary to enhance the formation of organic acids in the water, in which organic matter can be decomposed and dissolved. Molecule size distribution analysis showed 80% of the colored substances in the wastewater were composed of molecules > 50 KDa. When MSL systems got saturated with absorbed colored substances, most of decolorization and recovery processes were related with big molecules (>1000 KDa). Release of absorbed smaller molecules seemed to be the key to further improve the decolorization rate. Cation exchange resins showed higher decolorization rates than anion exchange resins, which was contrary to many of the literatures that the decolorization of livestock wastewater was mainly by anion exchange. Further study is necessary to get clear conclusions.