様式例：課程博士用

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論　文　要　旨(博士)

論文題目	分散型生活排水処理施設に適用可能な汚泥削減技術の開発に関する研究

(要旨　1,200字程度)

分散型排水処理施設の浄化槽は、公共用水域等の水質汚濁防止や生活環境の保全および公衆衛生の向上に寄与する恒久施設と位置付けられているが、単独処理浄化槽の合併処理化や浄化槽汚泥量の増加など大きな課題を抱えている。上記課題を解決するためには、浄化槽システム内で余剰汚泥の減量化が可能な汚泥削減技術の開発が不可欠である。

本研究では、高い MLSS と長い SRT の条件下で高い汚泥削減率が得られる高濃度好気性消化法に着目し、本法を浄化槽内に組み込んだ汚泥消化型浄化槽の開発を行うことを目的とし、(1)固定床循環ろ過による汚泥濃縮特性、(2)浄化槽汚泥の好気分解特性、(3)実証試験による排水処理性能と汚泥削減効果について実験的検討を行った。本論文は 7 章より構成されており、各章は以下のようにまとめられる。

第1章では、汚泥削減技術について取りまとめるとともに、浄化槽の課題として単独処理浄化槽の合併処理化とそれに伴う浄化槽汚泥の増加を指摘し、浄化槽へ適用可能な汚泥削減技術の開発の必要性について論じた。

第2章では、一般的なBOD除去型浄化槽に加え、高度処理型、ディスポーザ対応型の汚泥発生量と汚泥性状を把握することを目的とした。一日一人当たりの汚泥発生量は、BOD 除去型＝9.8g/人/日、窒素除去型＝8.5g/人/日、窒素リン除去型＝16.0g/人/日、ディスポーザ対応型＝25.0g/人/日であった。また、BOD 除去型と窒素除去型浄化槽は、蓄積汚泥の灰分比が低いことから、好気性消化による汚泥削減の効果が期待できることを示した。

第 3 章では、固定床循環ろ過方式という新たな汚泥濃縮技術を開発し、浄化槽汚泥の濃縮特性と汚泥削減効果について検討を行った。本方式では、80%以上の安定した SS 除去率が得られるとともに、MLSS を約 10,000mg/L まで濃縮できることを示した。

第 4 章では、好気性消化の汚泥分解率を高める方法として、高速旋回流発生装置の剪断力とアルカリの併用による汚泥改質処理の効果について検討を行った。改質処理を行うことで、98%の極めて高い汚泥分解率が得られたが、改質処理を行わない条件でも 86%の汚泥分解が可能であった。

第 5 章では、回分式好気性消化実験を行い、汚泥分解速度の挙動を把握するとともに、間欠ばっ気運転による生物学的窒素除去特性について検討を行った。生汚泥-連続ばっ気条件において72.8%の高い汚泥分解率が得られた。さらに、間欠ばっ気条件でのTN除去率は95%以上と極めて高く、連続ばっ気条件においても 73～86%の窒素除去が可能であった。

第6章では、5人槽規模の汚泥消化型浄化槽(実証試験槽)を製作し、排水処理性能、汚泥削減効果、ランニングコストについて既存の小容量型合併処理浄化槽との比較を行った。汚泥消化型浄化槽の処理水平均BODは約20mg/Lであったが、1年を通じて良好な処理性能を維持することはできなかった。しかし、小孔ピークカット機能やろ過機能を適用することで、処理性能の向上が期待できることを示した。実証試験槽は、既存小容量型合併処理浄化槽に比べ汚泥発生量を約 36%低減でき、ランニングコストも年間 25%削減可能と試算できた。

第7章では、本研究において得られた結果と今後の課題についてまとめた。

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論　文　要　旨(博士)

論文題目	**Development of sludge reduction technology for on-site household domestic wastewater treatment systems**

(Abstract)

Johkasou system (on-site domestic wastewater treatment system) as well as sewage treatment system is an important and essential system to control water pollution and for sanitation. However, some problems remain for Johkasou system: for example, exchanging Tandoku-shori Johkasou (treating only flash from toilet) for gappei-shori Johkasou (receiving both flash from toilet and gray water), and increasing excess sludge from Johkasou system. In order to solve theses problems, it is an important subject to develop sludge reduction technologies for household Johkasou system.

The main objective of this work is to develop a new type Johkasou combined with an aerobic sludge digestion unit in order to reduce excess sludge production. When an aerobic digestion process is operated under long sludge retention time (SRT) and high concentration of active biomass (MLSS), effective reduction of excess sludge is expected. For this reason, the following subjects were examined: (1) sludge thickening performance of a fixed bed filtration unit, (2) performances of aerobic digestion for the sludge accumulated in Johkasous working actually, and (3) design and setup of a pilot-scale Johkasou installed with a aerobic sludge digestion unit, and (4) the wastewater treatment and sludge reduction performances of the pilot-scale Johkasou. This thesis consists of the following 7 chapters.

Chapter 1: It was pointed out that the excess sludge from Johkasou system will increase by the popularization of gappei-shori Johkasous and that excess sludge production in household Johkasous should be reduced. The technologies for sludge reduction were reviewed and the objectives of this work were described.

Chapter 2: The sludge production rates of the household Johkasous working actually were investigated as basic data to design a new type of Johkasou installed with an aerobic sludge digestion unit. The following excess sludge production rates were obtained: 9.8 g/person/day for BOD removal type Johkasous, 8.5 g/person/day for nitrogen removal type Johkasous, 16.0 g/person/day for nitrogen and phosphorus removal type Johkasous, and 25.0 g/person/day for the Johkasous receiving waste from disposer. In addition, the sludge accumulated in the BOD removal types contained less ash component, and therefore the sludge was expected to be decomposed by aerobic digestion processes.

Chapter 3: Since effective sludge thickening technologies are required for effective digestion of excess sludge, a fixed bed filtration process was developed as a sludge thickening device in order to apply to household Johkasous. This system showed 80% of solids removal and retained high concentration of sludge (10,000 mg/L). The results indicated that the system can be employed as a sludge separation device for a small-scale aerobic digestion unit.

Chapter 4: In order to improve the performance of biological sludge decomposition, the following pre-treatment methods were examined: breaking sludge particulates by a high-speed revolution flow generator and/or alkaline treatment. The aerobic digestion after the pre-treatment gave 98% of sludge decomposition ratio, but the aerobic digestion without the pre-treatment also showed 86% of sludge decomposition ratio.

Chapter 5: The sludge decomposition rates for several types of sludge were examined by batch type aerobic digestion experiments, where intermittent aeration was also employed for biological nitrogen removal. When raw sludge in household Johkasou was treated under continuous aeration condition, 72.8% of sludge reduction and 71~86% of total nitrogen (TN) removal was obtained. In the case of intermittent aeration condition, more than 95% of TN removals were obtained.

Chapter 6: a pilot-scale Johkasou equipped with an aerobic digester for sludge decomposition was designed and setup. Actual domestic wastewaters were treated by the system, and the wastewaters were also treated by a conventional Johkasou in order to compare wastewater treatment performance, sludge production rate, and running cost. The average BOD of the effluent form the pilot-scale Johkasou was less than 20 mg/L, but the effluents containing more than 20 mg/L of BOD were observed some times. However, when a flow equalization device is employed, it is suggested that wastewater treatment performance is improved by reduction of peak flow. The accumulated sludge amount in the pilot-scale Johkasou was reduced at 64% in comparison with that of the conventional one. In addition, 25% of the running cost was also reduced.

Chapter 7: The results obtained in this work were summarized as conclusions. Based on the results obtained in this work, it was indicated that effective reduction of excess sludge production is able to be achieved by installation of an aerobic sludge digestion unit into Johkasou system. In addition, the subjects in future development of prototype of Johkasous to reduce excess sludge production were discussed.