VII－36　Behaviour of heavy metals through anaerobic, anoxic and aerobic treatment process of domestic wastewater

ANDRIANISA Harinaivo, HIROSHI Kawaguchi, ITO Ayumi, UMITA Teruyuki
Department of Civil and Environmental Engineering, Iwate University

1. Introduction

Heavy metals may be naturally present in the environment, or mostly come from industrial, municipal and urban runoff. Nowadays, they are one of the main sources of water and soil pollution, especially, when found at high concentration. Therefore, researches relating to their removal have been increased for the last decades.

In this research, behaviour of eleven metals (Al, Ca, Cr, Mn, Ni, Fe, Cu, Zn, Cd, Pb and As) in the Rikuzen Takada Wastewater Treatment Plant (RTWTP) was investigated to understand the mechanism of heavy metals removal.

2. Methodology

Description of the Rikuzen Takada Wastewater Treatment Plant

The RTWTP treats about 900 m^3/day of wastewater that comes from municipal uses and urban runoff. The treatment process is composed by a screening unit, grit chamber, primary sedimentation, the A2O (Anaerobic, Anoxic, Aerobic) process, secondary sedimentation tank and disinfection using UV light.

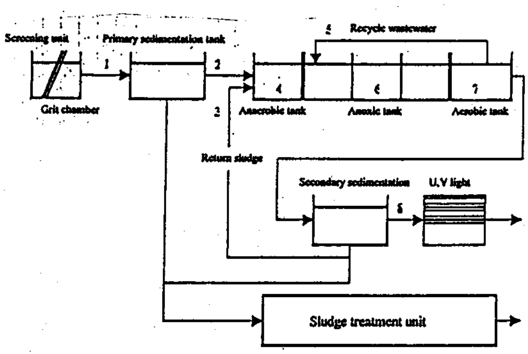

Fig. 1 Schematic diagram of the RTWTP

Sampling procedure

Samples were collected three times on September 04th, November 11th and December 18th, 2003. Eight points through the treatment process as indicated in Fig.1 were selected for the sampling: 1.influent, 2. after primary sedimentation tank, 3. return sludge, 4. anaerobic tank, 5. recycled wastewater, 6. anoxic tank, 7.aerobic tank and 8. effluent.

Three grab samples were collected from each designated point according to the Standard Methods for the Examination of Water and Wastewater to preserve the samples until analysis.

Samples preparation and analysis

The RWTP collects only domestic wastewater, which means that heavy metals concentrations are supposed to be very low.

Total and dissolved contents of metals were determined by ICP/MS (Inductively Coupled Plasma/Mass spectrometry) method according to the Japanese Standard Methods for the Examination of Wastewater.
Preparation of samples for dissolved metals analysis was carried out by centrifugation of the sample at 3000 rpm during 20 min and filtration with 1μm membrane filter.

Analysis were carried out in triplicates and the mean value of the two closer values was considered as the final result.

3. Results and discussion

Influent concentration

Influent metals concentrations varied greatly depending on the day when the samples were collected.
Ca concentration was always the highest followed by Al and Fe which order changed, next by Mn and Zn, then, the group of Pb, Cr, Cu and Ni. The metals with lowest concentration were As and Cd. In decreasing order, we have Ca>Fe, Al>Mn, Zn> Pb, Cr, Cu, Ni > As, Cd.

Total and Dissolved metals concentrations were almost equal. It can be said that influent metals are present in dissolved forms. The concentration order of dissolved metals was the same as that of total.

Overall removal efficiency

Removal efficiency depended on metal species and its influent concentration. But generally, for one given metal, when the order of influent concentration was same at different sampling day, their removal efficiencies were almost equal. For example, the case of Mn is shown in Table 1.

Table 1: Mn influent concentration and removal efficiency

	Sept		Nov		Dec	
	Conc.	Eff.	Conc.	Eff.	Conc.	Eff.
Total	0.42	84.4%	0.26	90.8%	0.044	10.9%
Dissol.	0.41	98.8%	0.27	92.1%	0.06	8.1%

To study the overall efficiency, influent metals concentrations with same order were considered and their mean values for both total and dissolved concentrations are shown in Fig.2.

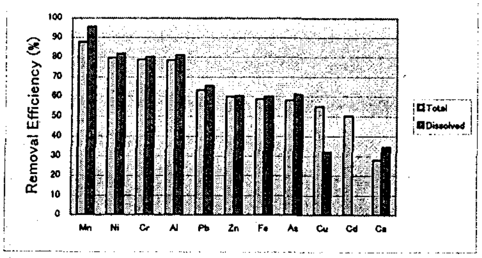

Fig.2 Overall Removal efficiency of metals

No metal was removed more than 90%. Removal of total Mn is the highest with 87.7%, while total Ca was the lowest with 28.0%. In descending order, dissolved and total metals removal efficiencies were similar, with the exception that dissolved As was immediately after Pb and Cd presented the lowest.

Removal in Primary and Secondary sedimentation tanks

Although heavy metals removal occurred in the primary sedimentation tank, it was relatively low. In some cases, total and dissolved heavy metals concentrations after the primary sedimentation were increased. On the other hand, the secondary sedimentation tank was very efficient to remove total metals after biological treatment. In exception for Ca and Cd that average removal efficiency for the three sampling times was 70% and 75%, the level of other metals efficiency was more than 80%. However, removal of dissolved metals was very low and increase of concentrations arised for most metals.

Removal in Biological Process

Metals concentrations before and after biological process were compared, using the concentrations of metals from primary sedimentation tank and return sludge and their flow rates as influent and those from the aerobic tank as effluent. Mean values during the three sampling days are shown in Fig.3.

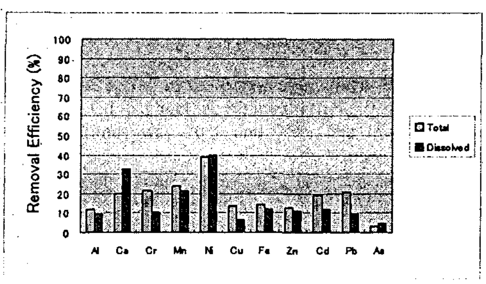

Fig3 Biological process removal efficiency

With less than 50%, heavy metals removal by this process occurred. In this process, Ni had the highest removal rate while As the lowest both for total and dissolved concentrations.

Dissolved and total metals removal efficiencies for each metal were similar for Ni, Fe, Zn and Mn. The efficiency of dissolved metals was higher than that of total for Ca and As, and lower for Al, Cr, Cu, Cd and Pb.

By comparing the concentrations for different sampling days, it was difficult to define an order of removal efficiency. For example, removal of Al was one of the lowest on September and November, but became one of the highest in December.

Removal in Anaerobic tank, Anoxic tank and Aerobic tank

Last, influent and effluent metals concentrations at each treatment tank of the biological process were compared.

Generally, anaerobic tank was reasonably efficient to remove Al, Cr, Mn, Ni, Cu, Zn, Cd and Pb while Ca, Fe and As concentrations did not vary.

In anoxic tank, with the exception of Fe where effluent concentration was greatly increased compared to influent and, Cr, Cu and As which showed a small inclination of removal, the general tendency of metals behavior could not be explained. For others metals, concentrations may significantly increased for one day while deeply decreased for another one.

Finally, small tendency of heavy metals removal can be noticed in the aerobic tank for most metals (Al, Ca, Mn, Ni, Cu, Fe, Cd) but still could not be defined for others (Cr, Zn, Pb, As).

4. Summary

The influent metals concentrations in the RWTP are very low because this plant treats only domestic wastewater. Overall metals removal efficiency varied from more than 80 % (Mn) to less than 30% (Ca).

Anyway, metals can be removed through each step of the treatment; relatively high in secondary sedimentation tank and less than 50% in biological treatment.

Last, the purpose of this research was to understand the behaviour of heavy metals during anaerobic, anoxic and aerobic treatment. It was evident that from the available data, it is still difficult to determine and to explain the mechanism of heavy metals removal inside these three treatments tanks. Further investigations are needed.