KUBOTA Submerged Membrane Unit®

Kubota

Membrane Now!

Summer, 2006
vol.01

Hi, do you know us?

Kazuma Abe

Profile
Kazuma Abe (ZACK)
General Manager
Membrane System Department
KUBOTA Corporation

He takes the leadership of our department with his keen foresight, which comes from his prolific international sales and marketing experiences for the past couple decades.

His motto is "Life is exciting challenge."

We are the leading manufacturers of submerged flat sheet membrane developed exclusively for wastewater treatment.

We are pleased to deliver the first issue of our "Membrane Now!".

We would like you to have better and correct information on our membrane and us.

The better you know our technology, the better you like Kubota!

Features

Water Quality Index for Industrial Wastewater

Taichi Uesaka

KUBOTA Submerged Membrane Unit® (Kubota SMU) is an immersed microfiltration membrane in activated sludge. The collaboration of suspended growth bioreactor with biomass separation, generally known as membrane bioreactor (MBR) technology, has been widely used to treat industrial wastewater. The commercial Kubota SMU installations in industrial wastewater treatment have been increasing. In fact, the number of new installation in Japan was 97 plants in the year of 2005, and has added up to over 600 plants cumulatively (as of April, 2006).

MBR is classified into activated sludge process, and it can treat various types of wastewater. Its operation is easy and stable under more flexible conditions compared to conventional activated sludge process. Therefore, its continuous increase in industrial wastewater application is well expected in the near future.

Profile

Taichi Uesaka　Hirakata R&D Center Membrane System Department

He arms himself with abundant knowledge in water and wastewater quality, and strives to develop Kubota MBR with his unique ideas.

His motto is "Good health is in the first place!"

Studies Done by Kubota

In Japan, Kubota normally has a pilot to check feasibility of Kubota MBR for the individual industrial wastewater before its actual application. In addition, Kubota analyzes the influent and effluent qualities during the commissioning of MBR. From those various pilot experiences, Kubota has collected extensive industrial wastewater data to be categorized and evaluated between the industries. In this report, accumulated biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) data are carefully analyzed, and the correlations among the characteristics are summarized.

With Respect to COD

COD is the amount of oxygen required to stabilize organic matter determined by using a strong oxidant. The oxidant used globally is potassium dichromate ($K_2Cr_2O_7$), while potassium permanganate ($KMnO_4$) is generally used in Japan where Cr usage is restricted. COD_{Mn} denotes the COD analyzed by $KMnO_4$ as oxidant, whereas COD_{Cr} represents that by $K_2Cr_2O_7$. Moreover, $K_2Cr_2O_7$ is more oxidative than $KMnO_4$. Although COD analysis used in most Japanese industrial wastewater treatment plant is by Mn, Kubota has been analyzing both COD_{Mn} and COD_{Cr} as often as possible since there are many overseas installations and applications of Kubota SMU.

Classification of Industries

【Wastewater (WW) from Food Product Industries】

In Japan, there is a discharge regulation by local government on the operations that demand a large amount of water in a region without municipal sewerage, which accepts wastewater from factory. In those regions, private wastewater treatment plants are set up. Food product industries have a tendency to adopt MBR technology. As a matter of fact, there are many MBR installations at various food product factories. The categories of food product industries are shown as follows:

Agriculture, Livestock & Fishery: wastewater from workshop adjacent to factory which handles livestock or dairy
Food Processing: wastewater from meat or fish processing factory
Sugar, Oil & Grain Crops: wastewater from sugar, starch or oil factory
Beverages: wastewater from soft drink factory, brewery or distilling industry

【WW from Industries other than Food Product】

If the main pollutant of wastewater from industries other than food product is organic and biodegradable, then it can be treated by MBR technology. MBR functions well in the above situation, as well. The following data show types of industries, excluding food product industries, in which MBR has already been applied to.

Chemicals & Chemical Products: wastewater with high organic content from solvents, paints, pharmaceutical and cosmetics factories
Laundry & Cleaning: wastewater from laundering clothes and linens, or from cleaning process at various factories which abundantly contains detergent and surfactant
Solid Waste: leachate from landfill
Milling/Machining: wastewater from milling or machining which contains lubricant or solvent

Please refer to the industry list in each category on the right page*1)

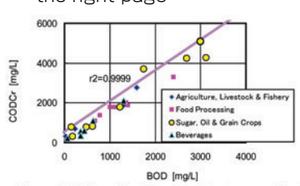

Fig. 1 WW from Food Product Industry COD_{Cr} vs BOD

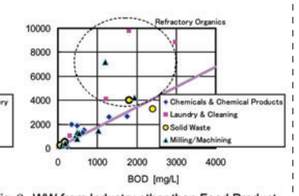

Fig. 2 WW from Industry other than Food Product COD_{Cr} vs BOD

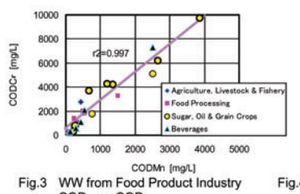

Fig.3 WW from Food Product Industry COD_{Cr} vs COD_{Mn}

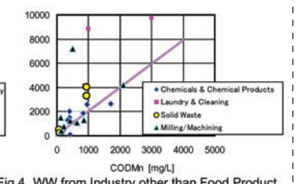

Fig.4 WW from Industry other than Food Product COD_{Cr} vs COD_{Mn}

Correlation of COD_{Cr} with BOD and COD_{Mn} of Industrial Wastewater

As shown in Fig. 1, it is said that the correlation between COD_{Cr} and BOD is mostly presented as COD_{Cr} = 1.7×BOD for wastewater from food product industries. It is also important to note that there is not much difference seen in correlation of COD_{Cr} with BOD depending on types of food industries. There may, however, be a slight correlation difference in terms of difference in dilution ratio. On the other hand, the correlation of wastewater from industries other than food product is shown in Fig.2. The COD_{Cr} is mostly 1.7 times BOD as observed in the food industries, however COD_{Cr}/BOD ratio for Milling/Machining and Laundry & Cleaning is rather as high as 5.5. This can indicate that Milling/Machining and Laundry & Cleaning contain refractory organics. Those not easily biodegradable materials are suspected to be mineral oil and detergent/surfactant.

As in Fig. 3 and Fig. 4, the ratios of COD_{Cr} to COD_{Mn} are COD_{Cr} = 2.5×COD_{Mn} for food industries and COD_{Cr} =2 to 9×COD_{Mn} for industries other than food product. The ratio differs largely depending on each industry.

In comparison, at domestic wastewater treatment plant the following ratios are acknowledged:
BOD:COD_{Mn} is approximately 200:100 in Japan,
whereas BOD:COD_{Cr} is approximately 150 to 200:300 in the rest of the world.

Removal Characteristics of MBR depending on BOD/COD_{Cr} Ratio

If a large part of organic in wastewater is not biologically degradable, the removal percentage of COD_{Cr} is expected to decrease. In MBR, activated sludge concentration is maintained high, which lengthen sludge retention time (SRT). In general, microorganisms, capable of degrading refractory organics, slowly grow. Therefore, if SRT is short, it is likely for the biomass to outflow from the treatment system. On the contrary, technology like MBR in which SRT is longer, it is possible for slowly grown microorganisms to stay in the system. In other words, MBR supports diversity of microorganisms. Thus, this characteristic of MBR can increase the ability of removing refractory organics compared to conventional activated sludge process.

By taking the lateral axis as biodegradability, indicated by BOD/COD_{Cr} ratio, a relationship between COD_{Cr} removal percentage and biodegradability is analyzed.

COD_{Cr} removal of more than 90% is clearly achievable for wastewater from food product industries. On the other hand, that of wastewater from industries other than food product ranges from 75 to 98%, and that of Milling/Machining tends to be lower since it contains mineral oil or its cleaning water. However, it can be concluded that COD_{Cr} removal of more than 90% is well expected.
In addition, BOD removal is mostly more than 98%. Even if BOD/COD_{Cr} ratio is low, almost more than 95% BOD removal is well expected.

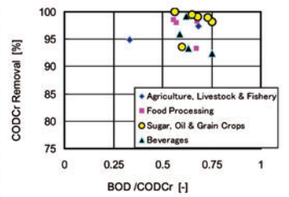

Fig.5 COD_{Cr} Removal for Wastewater from Food Product Industries

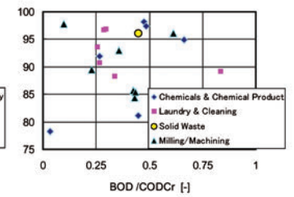

Fig.6 COD_{Cr} Removal for Wastewater from Industries other than Food Product

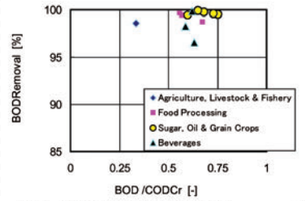

Fig.7 BOD Removal for Wastewater from Food Product Industries

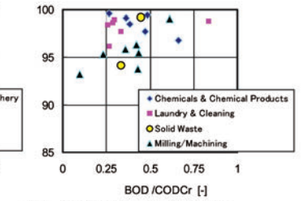

Fig.8 BOD Removal for Wastewater from Industries other than Food Product

※1) Details of Classified Industry

Wastewater from Food Product Industries

【Agriculture, Livestock & Fishery】
Aquaculture, Cattle Farming, Chicken Farming, Pig Farming, Dairy Industry
【Food Processing】
Seafood Product Industry, Dairy Product Industry, Vegetable·Fruit Canning Industry, Agricultural Preservative Product Industry, Frozen Seafood Product Industry
【Sugar, Oil & Grain Crops】
Bean Jam Manufacturing Industry, Starch Manufacturing Industry, Bakery·Confectionary, Noodle Manufacturing Industry, Grain Cleaning·Flour Refining Industry, Tofu·Bean Curd Manufacturing Industry, Fauna & Flora Oil·Fat Manufacturing Industry
【Beverages】
Soft Drink Manufacturing, Beer Manufacturing, Feed Mill·Fertilizer Mill, Liquor Manufacturing, Japanese Sake Manufacturing, Tea·Coffee Manufacturing

Wastewater from Industries other than Food Product

【Chemicals & Chemical Products】
Chemical Industry, Cosmetic Industry (Toothpaste included), Oil·Fat Processed Products·Detergent·Synthetic Detergent·Surfactant·Paint Manufacturing Industry
【Laundry & Cleaning】
Linen Supply Service, Laundry, Car Wash Industry
【Solid Waste】
Waste Disposal Industry, Slaughter Waste Disposal Industry
【Milling/Machining】
General Fandangle Manufacturing Industry, Information and Communication Devices (PC) Manufacturing Industry, Transport Equipment Manufacturing Industry

※2) BOD/COD_{Cr} is an index of biodegradability.
If the ratio is high, it means that there is a large ratio of organic material, which can be degraded by biomass.
Biochemical Oxygen Demand (BOD) is defined as the amount of oxygen required for the biological decomposition of organic matter under aerobic condition, which, in other words, measures biode-gradable organic amount. MBR treated water, normally, can remove BOD down to approximately 1 to 3 mg/L, which generally is the quantitation limit. However, depending on BOD load or imperfect performance of particular pilot system, organic matter in influent may be untreated and run off thus the removal rate can be decreased.

Exclusive Sales License Agreement of Membrane Performance Enhancer Finalized

PermaCare® Membrane Performance Enhancers (MPE), often referred to as flux enhancers (FE) or filterability modifiers, are specially formulated polymers designed for use in submerged membrane bioreactors (MBR) and membrane thickeners (MBT). Invented and developed over the past decade by the U.S. based Nalco Company (Naperville, IL), MPE remove fouling materials through flocculation and will not adhere to submerged membranes.

In cooperation with Enviroquip, Inc. (our U.S. Partner) and KUBOTA, Nalco have demonstrated the ability of PermaCare® MPE to increase membrane filtration rates (flux), improve effluent quality and reduce foaming caused by microbial activity. For example, in some studies MPE50™ was shown to increase sustainable flux at a given pressure by as much as 100% at low water temperatures. These findings along with full-scale data illustrate how the targeted use of MPE50™ can make MBR systems more economically viable in places like the northern U.S. and Canada where harsh winters are common.

On May 9, 2006, Nalco announced an exclusive agreement with Enviroquip, Inc. to market its PermaCare® MPE for municipal MBR applications in the U.S.. We believe that MPE should expand the market for KUBOTA Submerged Membrane Unit both in the U.S. and abroad.

—Kiyoshi Izumi

Replacement of Hollow Fiber Membrane Unit by KUBOTA Submerged Membrane Unit (Kubota SMU)

A company famous for factory outlet of various sweets, such as cake, ice cream and jello, decided to implement Kubota SMU (EK300×12units) into a wastewater treatment plant of its factory.
The plant is expected to treat 1,000m^3/d, and reduce BOD from 2,000mg/L to 10mg/L.

The wastewater treatment plant of the factory has been Membrane Bioreactor(MBR) system with hollow fiber membrane since 1996. The lease of hollow fiber membrane is coming to an end in this September, so the company well reconsidered which membrane should be used in it's factory. The company finally selected Kubota SMU because it is more popular in both the domestic and foreign sides, and tends to be a standard of MBR especially in Japan.

The factory has no holiday, so MBR can not be emptied. Therefore, the SMUs can not be set on the bottom of MBR as they always are recommended.
Thus, diffuser cases are set on the stand specially fabricated for the SMU and are dipped into MBR, in other words they are hanging on the top of the tank.

The hollow fiber membrane units are going to be replaced by 12 Kubota SMU, EK300, two by two for six times. This replacing method enables the plant to treat 1,000m3/d even during the replacement work.
The replacement work has started in the middle of July, and will have been finished by later August.

—Takahiro Suzuki

Largest KUBOTA MBR in the Western Hemisphere Nearing Completion

Innovative Design Will Be State-Of-The-Art In MBR Field

The largest Kubota flat-sheet membrane bioreactor (MBR) in the Western Hemisphere is nearing completion in Delphos, Ohio, USA and is due to begin operation in August 2006. The 6.0-MGD (22,700 m3/d) average daily capacity facility will also be the first system to incorporate Enviroquip's new StormMaster design, combining submerged membrane filtration and sludge thickening processes to economically handle high peak flows and loads.

Previously, wastewater treatment at the City of Delphos was conducted in an aging facility that was centered on trickling filter technology. As the City grew, the need to greatly expand the capabilities of the plant, both in terms of capacity and effluent quality, was becoming increasingly apparent. The existing facility was also situated directly within the main developed portion of the community, immediately adjacent to the City's recreational park. Relocating the facility outside the main developed area of the city would allow them to expand the park and improve the quality of life for the citizens of Delphos. A new MBR facility would provide additional capacity, greatly improved effluent quality and could be situated on a new site outside the City. Thus the technology was ultimately selected over more conventional activated sludge processes.

> "The membrane system is cutting edge. It's a flat sheet technology that will give us a great deal of flexibility with new EPA limits. This is a plant that will serve us well now and in the future.If we need to expand, it will be relatively easy."
> —Kim Riddell, Wastewater Superintendant, City of Delphos

The main challenge in the design of the MBR system was to be able to handle the wide variations in plant loading and influent flow without providing excess capacity that would be rarely utilized. The system handled municipal waste from the local community, high-strength waste from two large industrial contributors, and during rainfall and snowmelt conditions, high flows of urban runoff due to the presence of many old combined (sanitary/stormwater) sewer lines in the collection system. During peak storm events, flows to the facility are as high as 21.0-MGD (79,500 m3/d).

A portion of the flow to the plant could be equalized, but it was not economical to construct sufficient equalization volume to handle all of the peak flow above the average annual flow of 3.83-MGD (14,500 m3/d). It was also not feasible to install enough membrane capacity to handle the entire peak flow.

Following a detailed evaluation of the costs of constructing equalization versus membrane capacity, it was determined that a plant capable of handling 12.0-MGD (45,400 m3/d) would be the best approach. To further improve the economics of construction, Enviroquip's StormMaster design, where trains of membranes not required for treatment under average annual daily flow conditions are utilized to thicken waste activated sludge (WAS) prior to digestion and dewatering, was utilized. Under peak flow conditions, the basins normally thickening WAS could be immediately brought into service to process flow through the plant. This approach allows for useful employment of the additional trains required for peak flows, under normal flow conditions.

In order to meet effluent discharge limits, wastewater entering the new facility will pass through anoxic, aerobic and membrane filtration stages of treatment before final disposal. One hundred and thirty Kubota EK400 double-deck membrane units provide final filtration in the WWTP, making it the largest Kubota MBR in the Western Hemisphere, and for a while, the largest in the world. This unique facility will allow Delphos to easily expand capacity in the future, as several nearby communities may also eventually be serviced by the facility.

Construction of the $36M (US) facility began in February 2005 (complete cost of facility, including MBR system, sludge digestion and engineering). A Grand Opening ceremony is planned for the opening and the facility will be open for tours shortly thereafter. Contact Jim Porteous at Enviroquip (jim.porteous@enviroquip.com) for additional details.

—Ian C. Page, P.E.
National Applications Manager, Membrane
Division of Enviroquip, Inc.
However, he is currently with ADI Systems Inc.
located in Salem, NH, in the US since May 2006.

The City of Delphos Wastewater Treatment Plant Under Construction

Report "NEF Summit Meeting Held in Japan"

(at Osaka Headquarter and Hanshin Office of KUBOTA Corporation)

From May 9 to 12, 2006, KUBOTA Corporation hosted the first National Engineering Firms (NEF) Summit Meeting at the Osaka Headquarter and Hanshin Office, with internationally well known national engineering firms including CH2MHill, Earth Tech, MWH, M&E, CDM, Black & Veach, HDR, and Carollo Engineers. Setting our hope in mutually understanding potentials of both U.S. Membrane Bioreactor (MBR) market and KUBOTA Submerged Membrane Unit® (Kubota SMU), the productive, consecutive meetings were held as follows:

NEF SUMMIT MEETING SCHEDULE

May 9	Morning	Intro to KUBOTA Submerged Membrane Unit® History & Development of KUBOTA Submerged Membrane Unit®
	Afternoon	KUBOTA Submerged Membrane Bioreactor Process Application in the UK (Dr. Steve Churchhouse) Shop Tour: Kyuhoji Business Center
May 10	Morning	Plant Tour: Fukuzaki Town Sewage Treatment Facility
	Afternoon	Japanese Experiences with MBR for Wastewater Treatment (Dr. Takao Murakami, Japan Sewage Works Agency) Competitive Bidding and Evaluation of MBR Equipment (NEF) MBR Designs & Installations around the World (NEF) The US MBR Business, Design, and Installation (Enviroquip)
May 12	Morning & Afternoon	NEF's Input to KUBOTA/Enviroquip
	Afternoon	Introduction to KUBOTA Pumps and Ceramic Filter and etc…

FIRST DAY(May 9)

On the first day, we presented Kubota SMU basics and its development history, which was followed by Kyuhoji Business Center tour, where NEF could actually take a close look at the product itself.

Dr. Steve Churchhouse, a pioneer of SMU pilot and MBR applications in England, such as the first European SMU installation in Porlock STP, proved and presented Kubota membrane's durability and credibility by scrutinizing the actual long-term operational data obtained at the Porlock. The plant has been operated since 1998; however, only 43 membrane cartridges out of 3,600 cartridges have been replaced to date (98.8% original cartridges). In addition, he presented that both the treatment capacity and quality have been achieved as designed.

SECOND DAY(May 10)

On the second day, the drizzling morning started off by driving down a winding country road to Fukuzaki Town Sewage Treatment Facility, the first Municipal MBR facility in Japan. Then, another tough consecutive meetings were held in the afternoon, this time, for Kubota to understand deeply a competitive bidding and evaluation of the US municipal project.

In summary, the North America MBR evolution can be divided into four different generations, three generations have been evolved to date and the fourth generation has arrived. In the first generation, MBR was applied mainly to small package plant installed in places, such as trailer parks, ski resorts, and office complexes. The MBR technology attracted everyone's attention at the time because of its advantages, such as biological robustness, long sludge retention time (SRT), less waste sludge generation and superb effluent quality. In the second generation, in addition to the first generation a biological nutrient removal, especially total nitrogen and/or phosphorus, is accomplished. In the third generation, various membrane manufacturers strove to enhance flux, while engineers tried to lessen SRT and MLSS concentration so as to decrease capital cost and operation cost of MBR in total. Those costs were often considered to be shortcomings compared to those of conventional activated sludge process. In this generation, it was apparent that responsibilities for consulting engineers, such as thoes who visited Japan this time, were increasing. Therefore, this meeting was the best opportunity for both of manufacturer and consultants to share the knowledge, which will eventually help expanding the MBR market in North America. At present, the MBR in North America has reached to its fourth generation. In the fourth generation, the MBR application to large plants (Plant capacity: 5,000 to 50,000m^3/d) is the main focus. It currently tends that when applying MBR to large plants selection of the membrane equipment is independent of the MBR process and the plant design. However, we hope that as a result of this meeting membrane equipment selection for large plant will be considered with MBR process as a whole in an upcoming generation.

As for the competitive bidding and evaluation of US municipal projects, even for breakthrough technologies, such as MBR, engineers and clients believe that a competitive bidding environment promotes the most favorable cost and quality. Criteria clients evaluate include both financial and non-financial information. The financial information composes total capital cost, total life cycle operating, maintenance and replacement costs. On the other hand, the non-financial information consists of things such as complexity and effectiveness of cleaning system, history and projected life of membrane equipment, specific MBR application experience and corporate commitment to the marketplace. Clients and engineers tend to select MBR equipment at an early stage of the project, so it is important to get involved in the municipal projects as early as possible.

THIRD DAY (May 11)

A bit of break on the third day, we had a half-day trip to the most beautiful city in Japan, Kyoto. The attached picture proves the success of the NEF Summit meeting!!!

THE LAST DAY (May 12)

On the last day, to sum up the meeting, all the members of NEF presented how they see MBR technology and its future along with how US market is shifting. The meeting has concluded not only with the mutual understanding of Kubota SMU , MBR and its potential market, but also new assignments left to all the members of NEF and KUBOTA.

As conclusion, this is only the first meeting, of which the follow-up meetings with each firm will be promptly taken care of by KUBOTA Membrane USA Corporation (a subsidiary of KUBOTA Corporation based in Bellevue WA), even as we speak. We hope to share more information with you in the near future.

—Haruka Shino

First Row from Left

Mr. George Virtue Crawford, Principal Engineer - Wastewater Treatment at CH2MHILL
Kazuhisa (Kaz) Nishimori, Technical Coordinator, KUBOTA Membrane USA Corporation
Keishi (KC) Oohata, Overseas Sales Group, Membrane System Department

Second Row from Left

Dr. Glen Thomas Daigger, Senior Vice President and Chief Technology Officer, CH2MHILL
Mr. Dennis Livingston, Application Manager, Enviroquip Inc.
Haruka Shino, Technical Group, Membrane System Department

Third Row from Left

Mr. Johannes Bernardus (J.B.) Neethling, Senior Vice President, HDR Engineering, Inc.
Mrs. Patricia Daigger
Ms. Cindy Lynn Wallis-Lage, Chief of Proess Technologies Director of WWT Technologies Dept., Black & Veach Corporation
Ms. Elena Baily, Process Application Director, Enviroquip Inc.
Mr. Stephen Michael Lacy, Principal Engineer, Montgomery Watson Harza Americas, Inc. (MWH)

Last Row from Left

Mr. Brian Thomas Harrington, Vice President, Metcalf and Eddy, Inc. (M&E)
Mr. Roderick David Reardon, Vice President, Camp Dresser and McKee (CDM)
Mr. James Phillip Hagstrom, Partner, Carollo Engineers, P.C.
Hiroyuki Takatori, President, KUBOTA Membrane USA Corporation
Kazuma (Zack) Abe, General Manager, Membrane System Department
Mr. Terry L. Krause, Vice President - Wastewater Technical Practice Leader, Earth Tech
Dr. Steve Churchhouse, KUBOTA Membrane Europe Ltd.

Extra

Who Are We, "Membrane R&D Center"? ~①~

In the article 'Water Quality Index for Industrial Wastewater', we have mentioned that Kubota runs performance tests of MBR, and conducts water quality tests of influent and effluent during the MBR commissioning.

The staffs who are responsible for all of these pilots and analyses are in KUBOTA "Membrane R&D Center" (Center). To begin with, we would like to introduce the analysis of water-quality undertaken in the Center.

There is a laboratory equipped with a variety of analyzing instruments in the Center. In this laboratory. we analyze important criteria for evaluating and maintaining water quality of plants, such as SS, COD_5, COD_{Cr}, COD_{Mn}, T-N and T-P, in accordance with Japanese Industrials Standards(JIS) and the general analyzing methods in sewage treatment in Japan published by Japan Sewage Works Association. Last year, we have surprisingly analyzed more than 1,500 samples! Evaluation and accumulation of these data develops our important technical faculties of MBR. Consequently it makes sure that you are satisfied with Kubota MBR technology.

In addition, the staffs who are in charge of these analyses are two ladies, Mrs.Okamoto and Mrs. Kimura as shown in the picture. They have gotten correct data with their efficient, accurate handling and their good team play.

Kubota promises to go on helping you with the firm faculty of analysis.

—Yukako Morita

"In a Laboratory of the Membrane R&D Center"
(Front: Mrs. Okamoto, Back:Mrs. Kimura)

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● Should you have any inquiry concerning "Membrane Now!", please connect to the following URL:
http://env.kubota.co.jp/membranenow/contactus/english