The Application of Biological Processes in Several Industrial Wastewater in Indonesia

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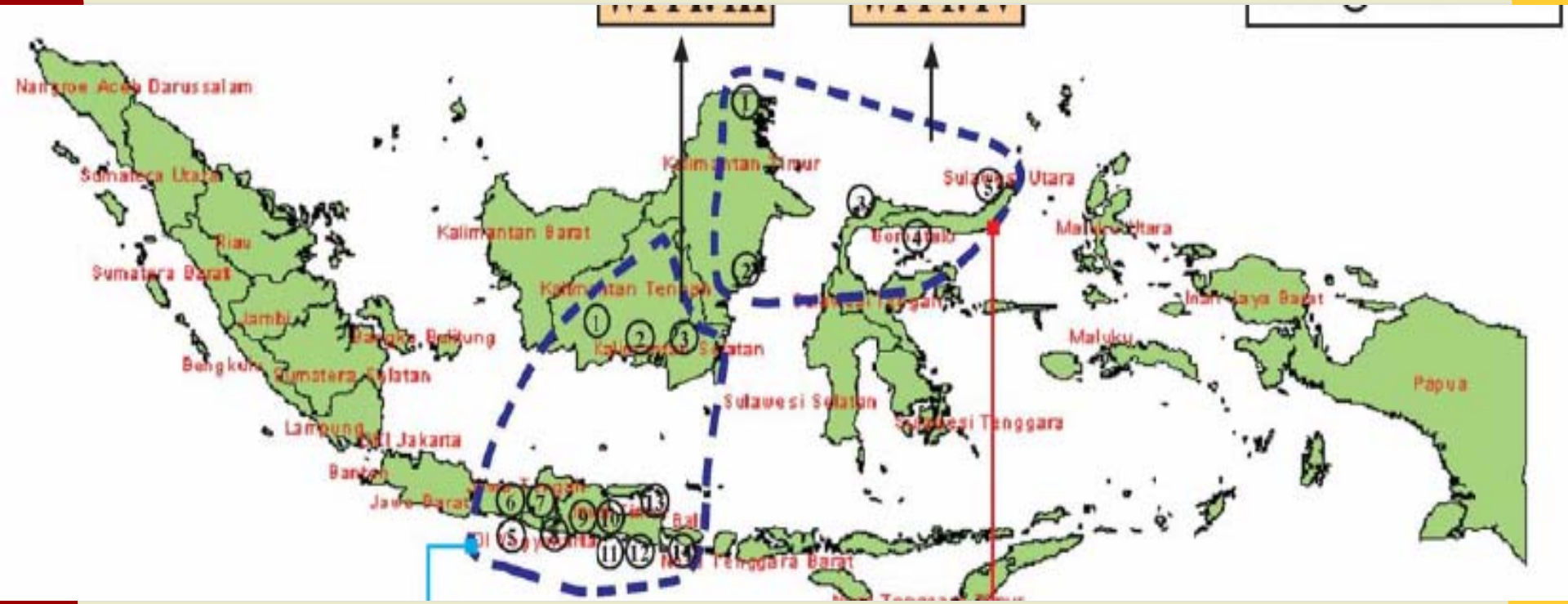
Outline of this paper

- Global Climate Change Effect to Indonesia
- Water Environment in Indonesia, in general
- Application of Biological Procesess in several industrial wastewater:
  - Membrane Bioreactors (MBR)
  - Production of Biodegradable Plastic (PHA)
  - Color Removal Using an Eco-Friendly Technology
  - Application of Anaerobic Processes for Treament of Industrial Wastewater

EAST ASIA

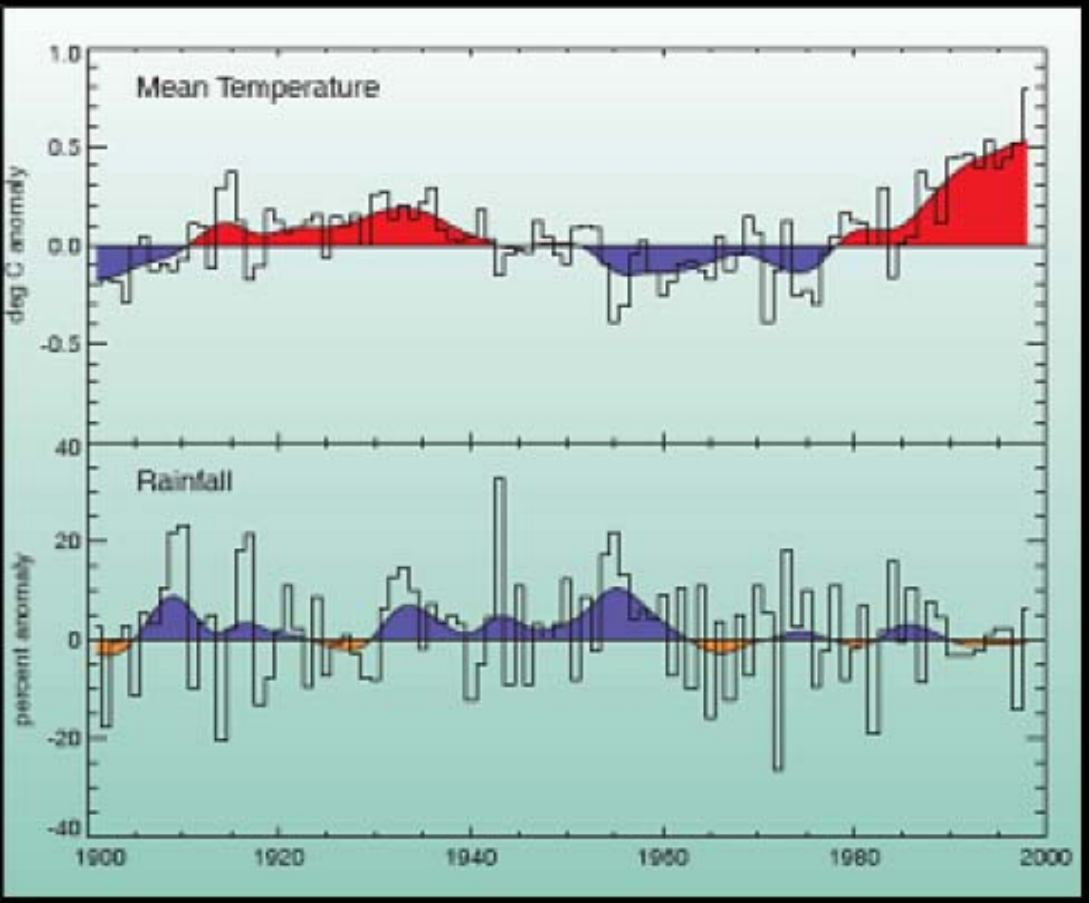

MONGOLIA
ULANBATOR
SHENYANG
HOKKAIDO
JEPANG
TOKYO
RAKYAT
CHINA
(RRC)
TAIPE
TAIWAN
REP. SOSIALIS
VIETNAM
MANILA
FILIPINA
THAILAND
BANGKOK
MINDANAO
MALASYIA
SINGAPURA
MALUKU
JAKARTA
KEP. NUSA TENGGARA

INDONESIA


Nanggroe Aceh Darussalam
Sumatera Utara
Riau
Sumatera Barat
Jambi
Bangka Belitung
Bengkulu
Sumatera Selatan
Lampung
DKI Jakarta
Banten
Jawa Barat
Kalimantan Barat
Kalimantan Timur
Kalimantan Tengah
Kalimantan Selatan
Sulawesi Utara
Gorontalo
Sulawesi Tengah
Sulawesi Selatan
Sulawesi Tenggara
Maluku Utara
Maluku
Irian Jaya Barat
Papua
Bali
Nusa Tenggara Barat

Global Climate Change Effect to Indonesia

Observed Climate Change in Indonesia



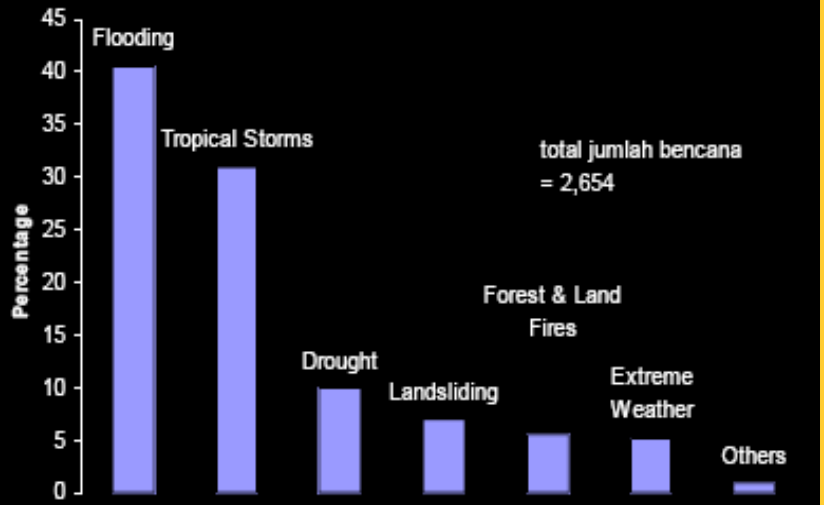
Hulme and Sheard (1999), and Boer and Faqih (2004)

- Temperature increased by 0.3°C
- Annual precipitation decreased by 2-3%
- Changes in precipitation patterns (decline in the south, increase in the north)
- Seasonality precipitation changes (wet season rainfall increased in the south; dry season rainfall in the north decreased)

Impact: Water and Food Availability

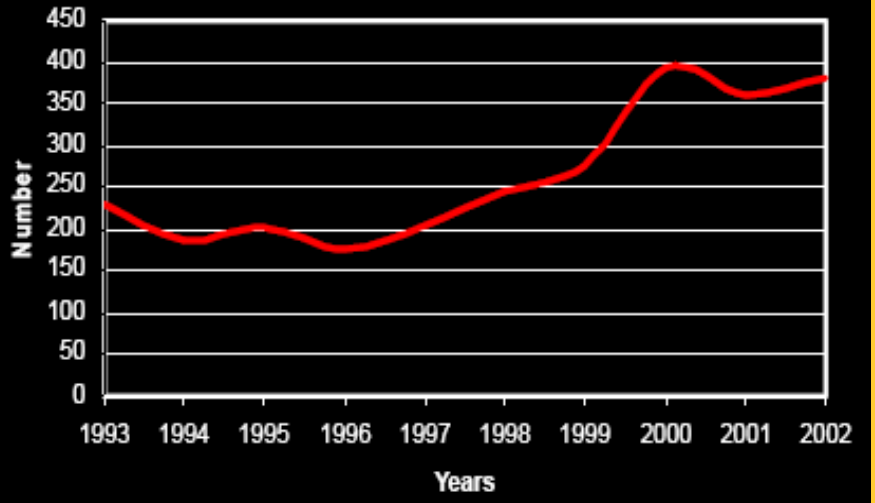
Decreased rainfall during critical times →

- high drought risk,
- uncertain water availability,
- uncertain ability to produce agricultural goods,
- economic instability,
- more undernourished people,
- hindering progress against poverty and food insecurity (Wang et al., 2006)



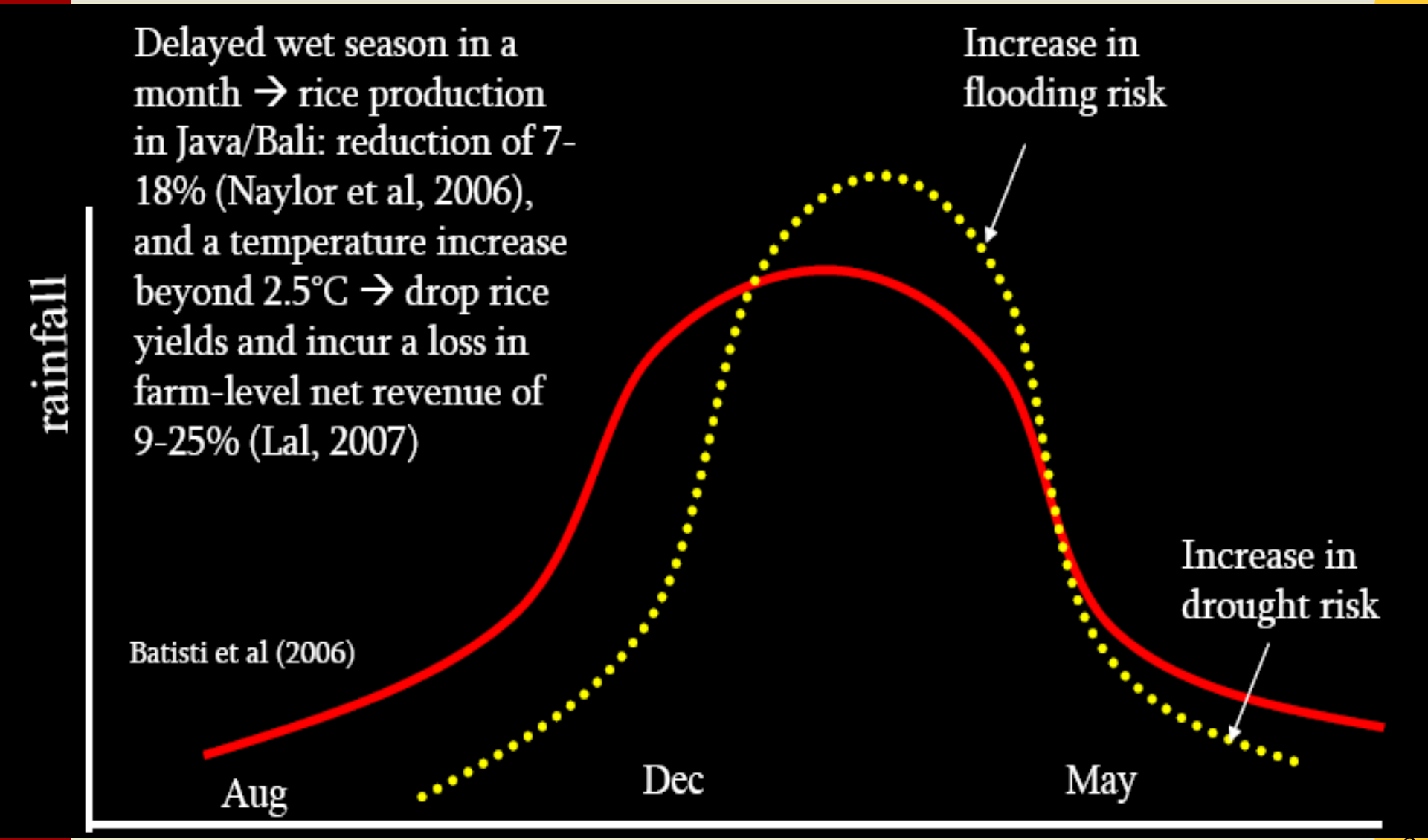
Increased rainfall in wet times →
high flood risk,

- e.g. the Jakarta flood on 2 February 2007 inundated 70,000 houses, displaced 420,440 people, killed 69 people, losses of Rp 4.1 trillion (US$ 450 million) (WHO, 2007, Bappenas, 2007)

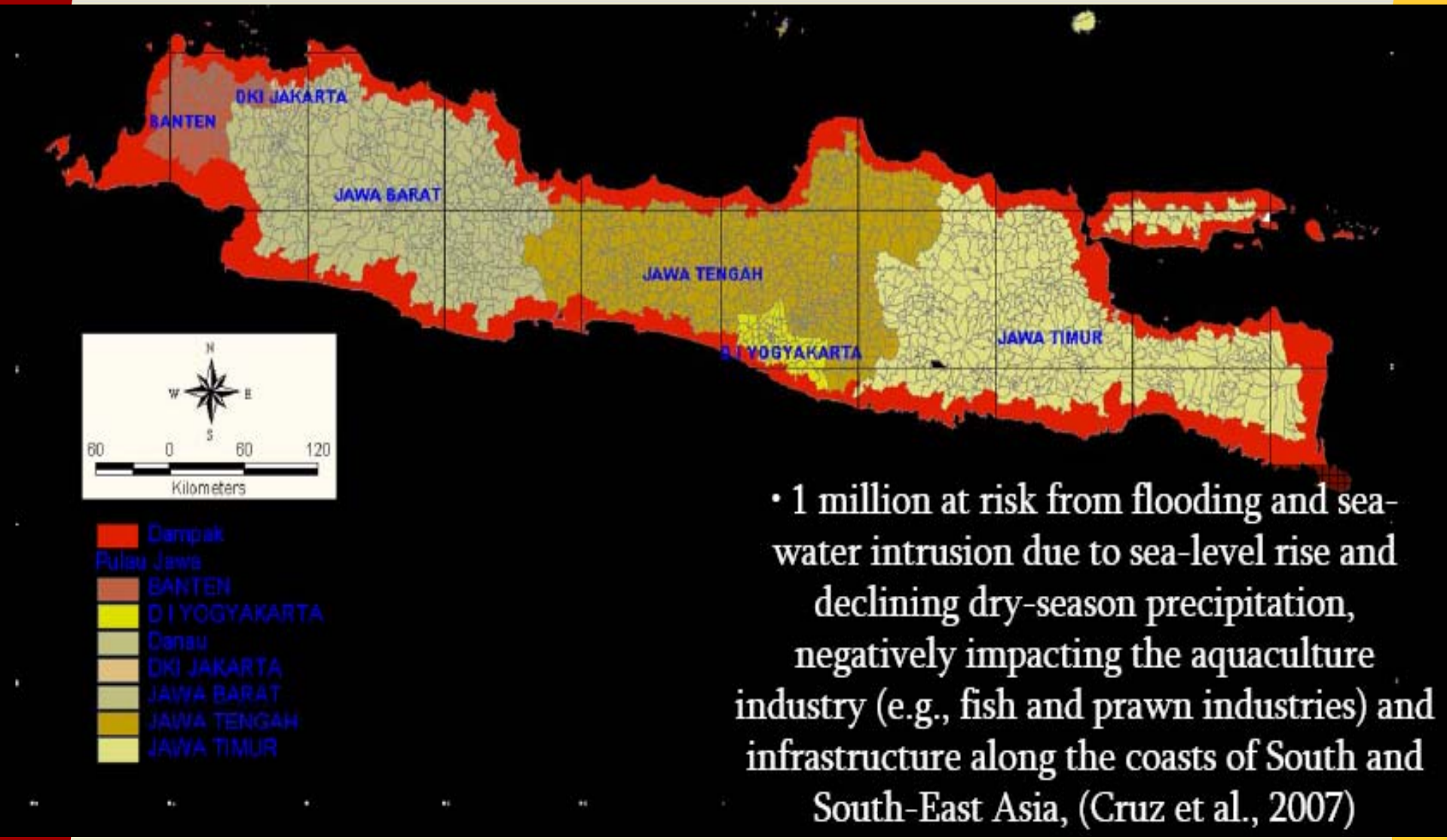


Stronger, more frequent El Niño →
more drying & flooding

Impact: Water and Food Availability



Impact Sea Level Rises in Java Island



• 1 million at risk from flooding and sea-water intrusion due to sea-level rise and declining dry-season precipitation, negatively impacting the aquaculture industry (e.g., fish and prawn industries) and infrastructure along the coasts of South and South-East Asia, (Cruz et al., 2007)

Water Environment in Indonesia, in general

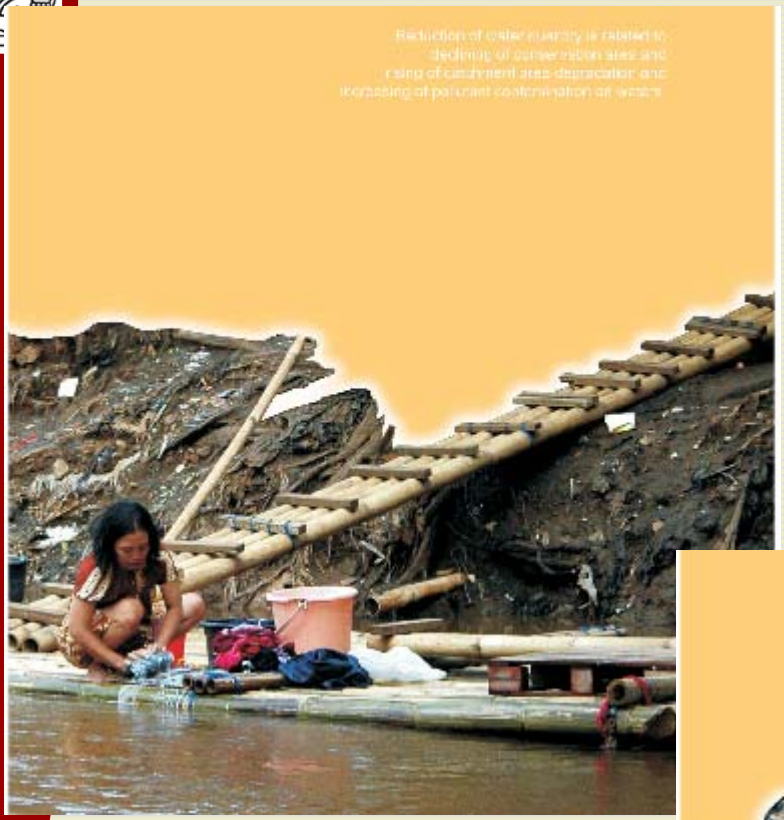
River Quality in Indonesia (2006)

No.	River	Province	Number of Points	Quality Status
1.	Krueng Aceh	NAD	6	Lightly polluted
2.	Deli	North Sumatra	11	Polluted - heavy polluted
3.	Batang Agam	West Sumatra	6	Compliant - lightly polluted
4.	Kampar	Riau	10	Lightly polluted - polluted
5.	Indragiri	Riau	14	Lightly polluted - polluted
6.	Rokan	Riau	15	Lightly polluted - polluted
7.	Siak	Riau	14	Lightly polluted - polluted
8.	Batanghari	Jambi	12	Heavy polluted
9.	Air Bengkulu	Bengkulu	6	Lightly polluted
10.	Musi	South Sumatra	8	Polluted
11.	Rangkui	Bangka Belitung	6	Polluted - heavy polluted
12.	Way Sekampung	Lampung	6	Polluted - heavy polluted
13.	Ciliwung	DKI Jakarta	15	Lightly polluted - heavy polluted
14.	Kali Angke	Banten	6	Polluted - heavy polluted
15.	Citarum	West Java	6	Polluted - heavy polluted
16.	Progo	Central Java	6	Polluted
17.	Progo	DI. Yogyakarta	7	Heavy polluted
18.	Brantas	East Java	18	Polluted - heavy polluted

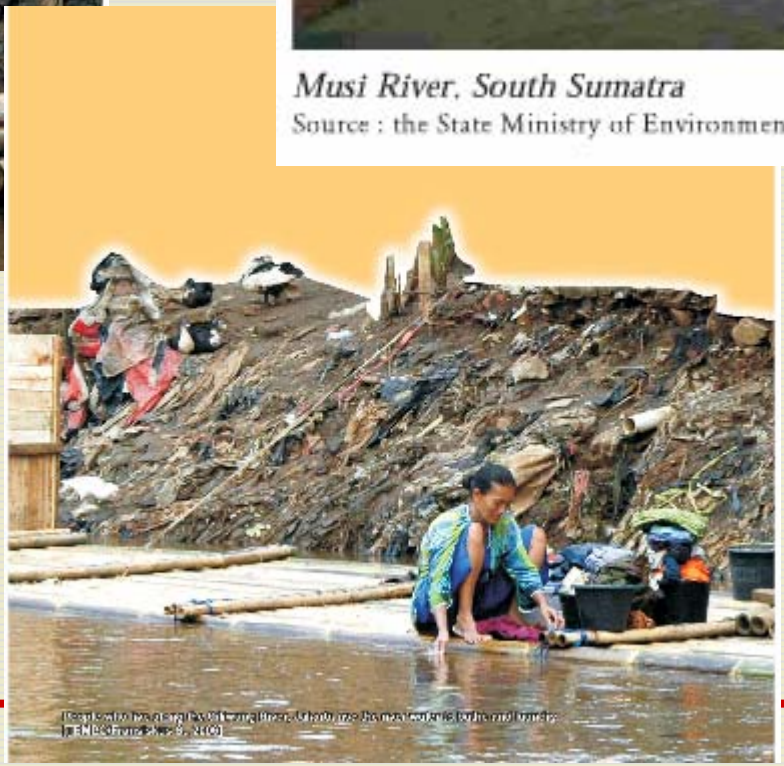
River Quality in Indonesia (2006)

19.	Tukad Badung	Bali	6	Lightly polluted - heavy polluted
20.	Jangkok	Nusa Tenggara Barat	6	Compliant - lightly polluted
21.	Dendeng	Nusa Tenggara Timur	5	Compliant - lightly polluted
22.	Kapuas	West Kalimantan	6	Lightly polluted - heavy polluted
23.	Mahakam	East Kalimantan	6	Polluted - heavy polluted
24.	Kahayan	Central Kalimantan	6	Polluted - heavy polluted
25.	Martapura	South Kalimantan	6	Polluted
26.	Bone	Gorontalo	6	Polluted
27.	Tondano	North Sulawesi	8	Polluted - heavy polluted
28.	Palu	Sulawesi Tengah	6	Lightly polluted
29.	Tallo	South Sulawesi	6	Compliant - polluted
30.	Jeneberang	South Sulawesi	6	Lightly polluted - polluted
31.	Konaweha	Sulawesi Tenggara	6	Compliant - lightly polluted
32.	Batu Gajah	Maluku	3	Lightly polluted - polluted
33.	Batu Merah	Maluku	3	Lightly polluted - polluted
34.	Tabobo	North Maluku	6	Lightly polluted - polluted
35.	Anafre	Papua	6	Compliant - polluted

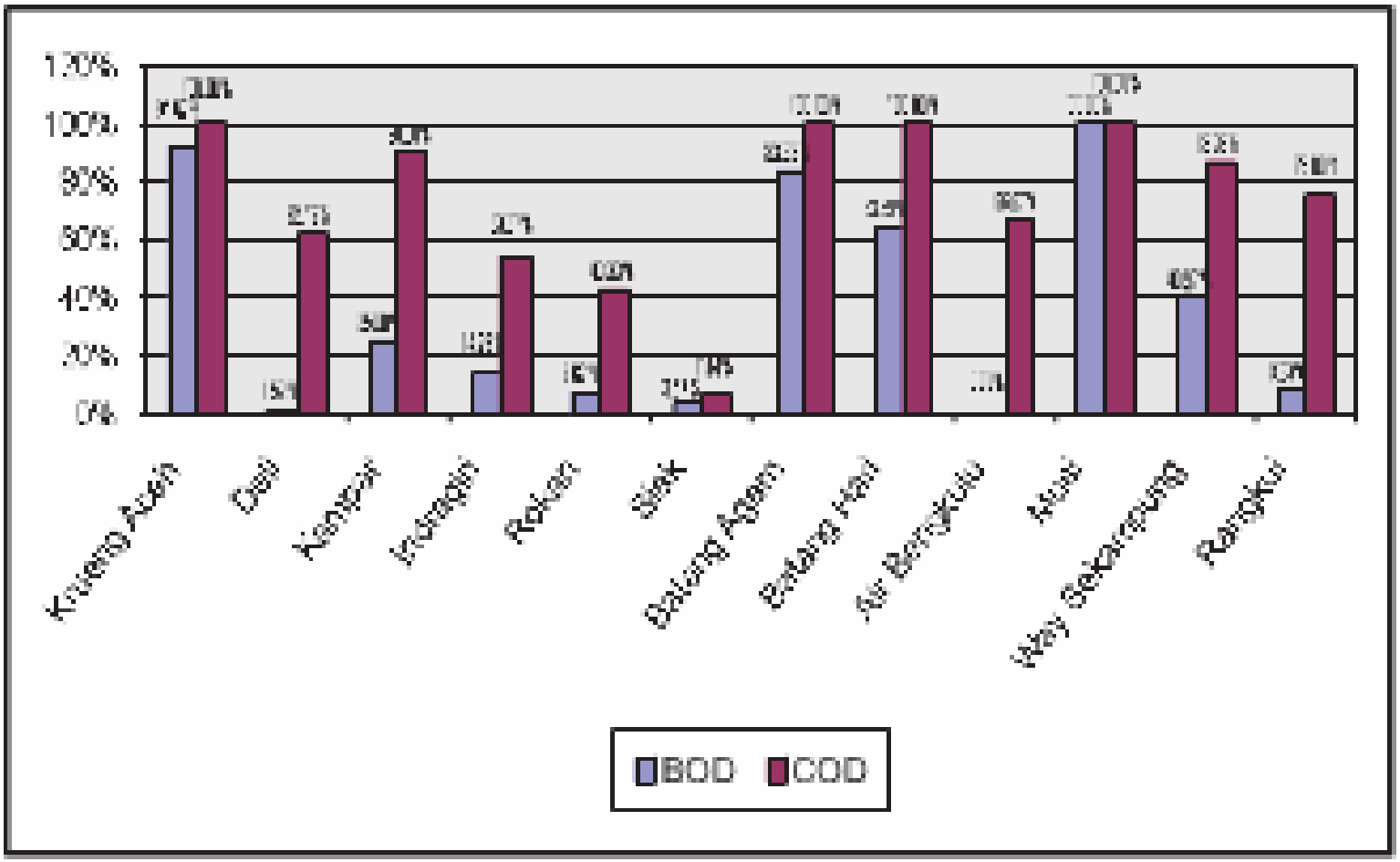
Source : Monitoring Reports on River Water Quality in Year 2006, the State Ministry of Environment (MoE)



Musi River, South Sumatra
Source : the State Ministry of Environment (MoE), 2006

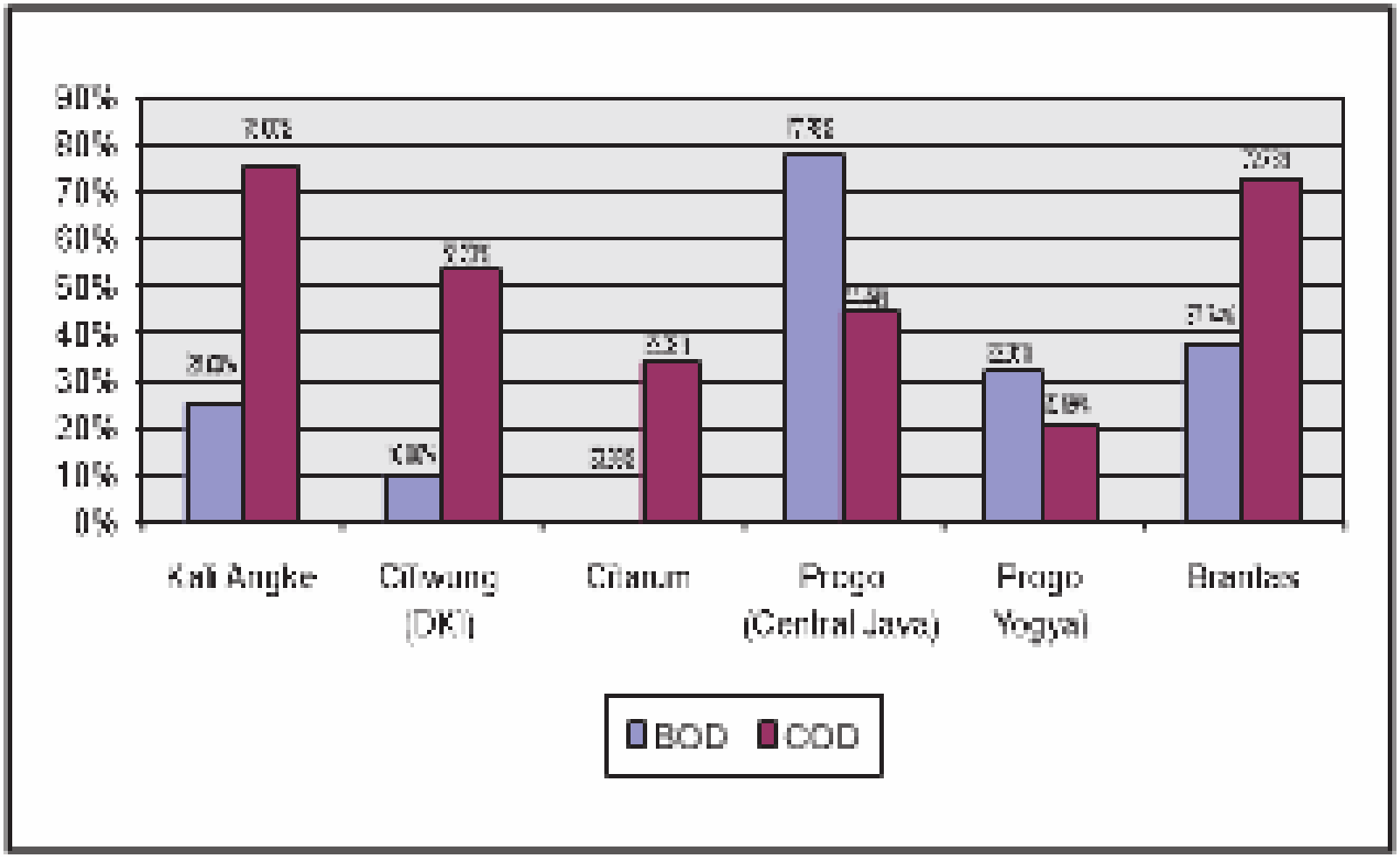


Picture 4.1 Percentage of samples of river water in Sumatra compliant to the water quality criteria of class II for BOD and COD in 2006



Source : MoE, 2006

Picture 4.2 Percentage of samples of river water in Java compliant to the water quality criteria of Class II for BOD and COD in 2006

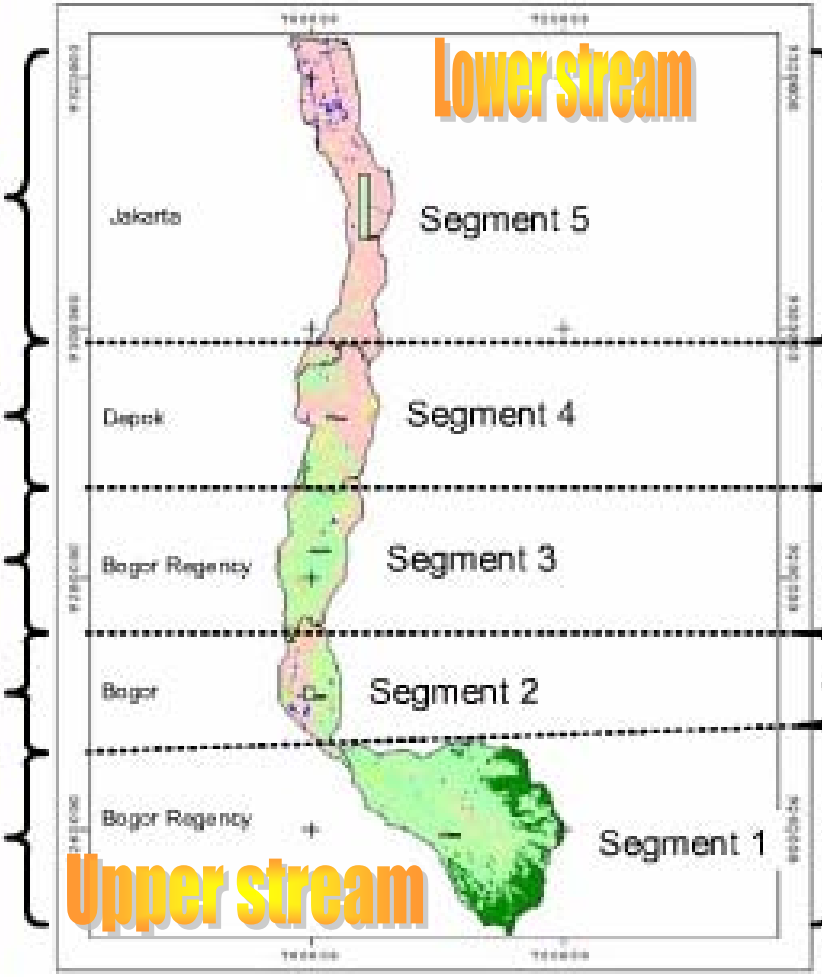


Source : MoE, 2006

Ciliwung river, Jakarta

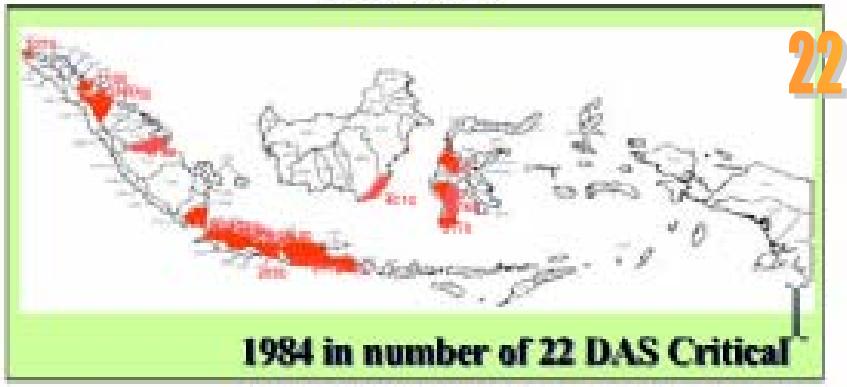
Condition of water quality of Ciliwung river at the moment and five year target of water quality

Present	Target of water quality 5 th	10 th	15 th
Not included in classes	Class IV	Class III	Class II
Class IV	Class III	Class II	Class I
Class III	Class II	Class I	
Class IV	Class III	Class II	Class I
Class II	Class I		

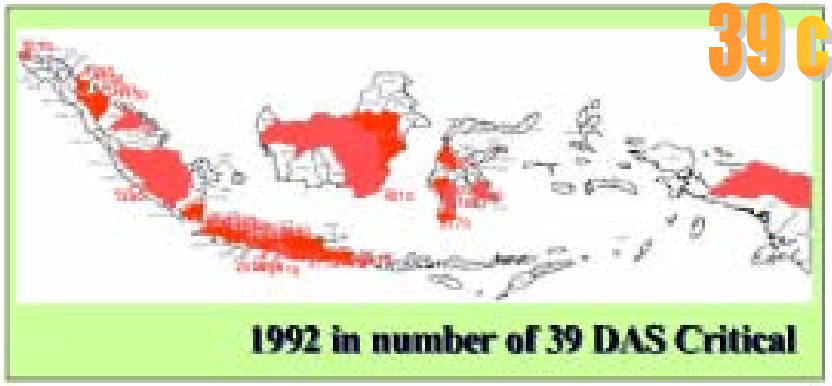


Source : The State Ministry of Environment, 2005

Critical river bank areas in 1984, 1992, and 2005



22 critical (1984)



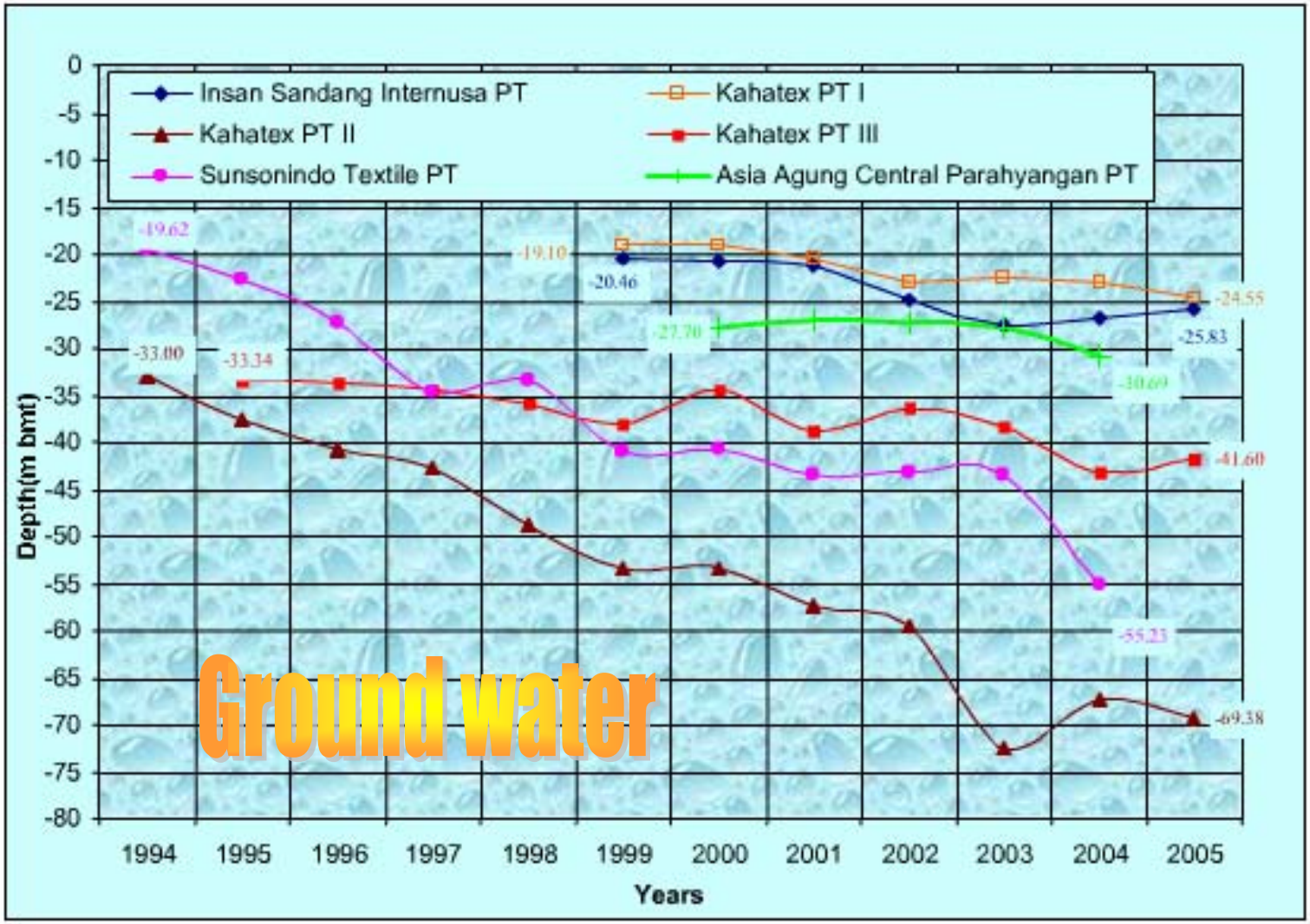
39 critical (1999)

62 critical (2005)

Source: Directorate General of Water Resources, Department of Public Work, 2005

Picture 3.31

Annual average ground water surface hydrographic on monitoring well in Rancaekek, East Bandung



Point and Non-Point Sources

Table 4.12 Number of Small Industries Having Potential to Contaminate Surface Water and Ground Water Years 2001 - 2004

No.	Type of Industry	2001	2002	2003	2004
1	Food and beverages	60,020	83,372	72,756	78,449
2	Textiles and leather	57,774	43,512	40,846	53,203
3	Chemicals	289	2,384	1,893	2,517

Source : Indonesia's Statistics 2004, BPS

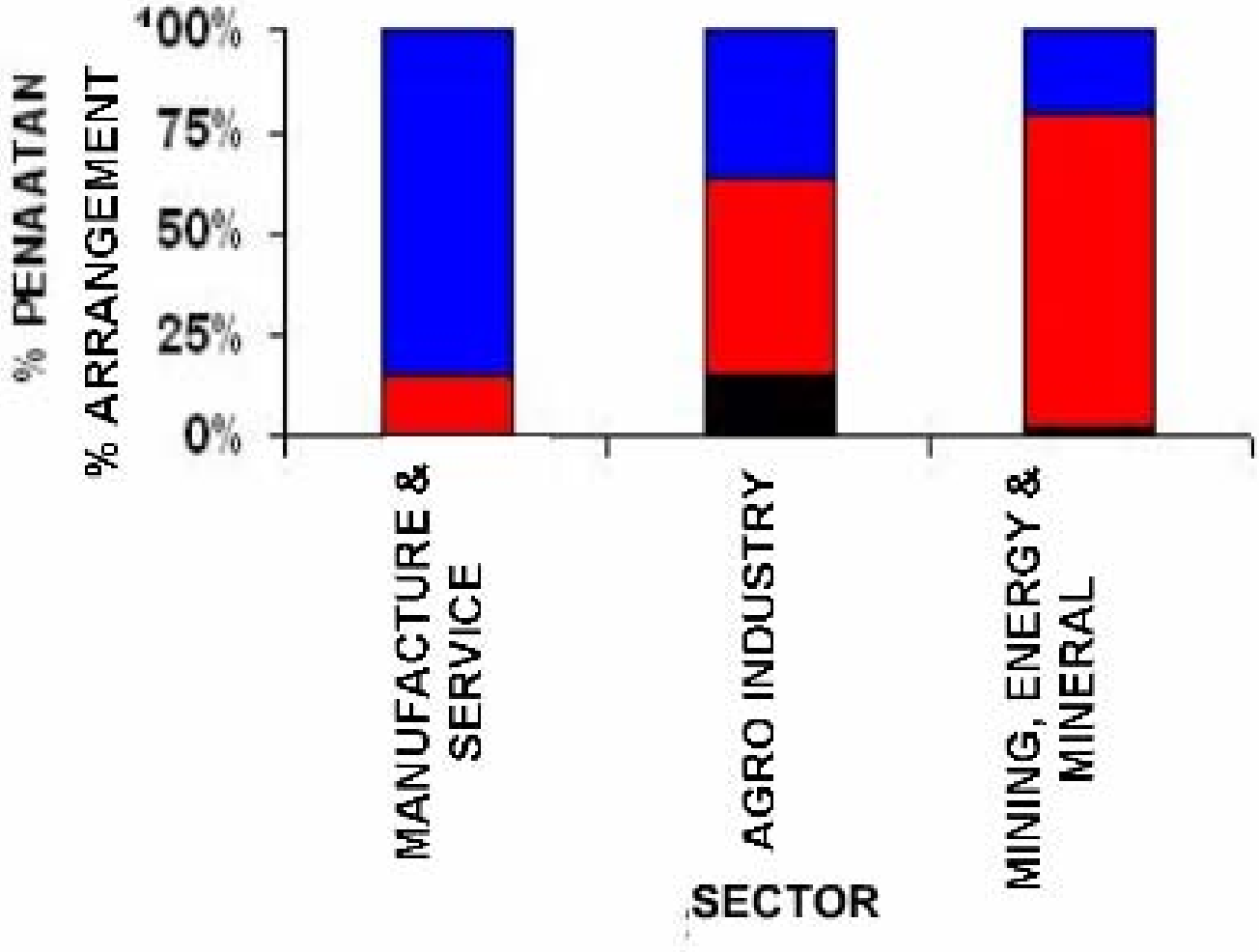
Table 4.13 Use of Inorganic Fertilizers and Pesticides in Ponds by Area in 2004

No.	Type of Industry	Inorganic Fertilizers (kg)	Pesticides (kg)
1	Sumatra	537,126	52,718
2	Java	231,443	54,102
3	Bali & Nusa Tenggara	40,321	223
4	Kalimantan	20,577	11
5	Sulawesi	680,685	2,140
6	Maluku & Papua	–	–

Source : Environmental Statistics 2005, BPS

Percentage of compliance in PROPER PROGRAMME (2005 – 2006)

Temporary Evaluation Result of Proper in the evaluating period of 2005–2006 (water pollution control aspects)



Source : The State Ministry of Environment, 2005

The Current Research on Application of Biological Processes in Industrial Wastewater

The current research

- Membrane Bioreactors
- Production of Biodegradable Plastic (PHA)
- Color Removal Using an Eco-Friendly Technology
- Application of Anaerobic Processes for Treament of Industrial Wastewater
- Other researches relating to Waste to Wealth
  - Recovery of Extra-cellular Polysaccharides from Waste Activated Sludge to use as Heavy-metals Adsorbent
  - Ethanol Production from Glycerol (a by-product of biodiesel industries)
  - Acetic Acid Production from Stillage of Ethanol Industries

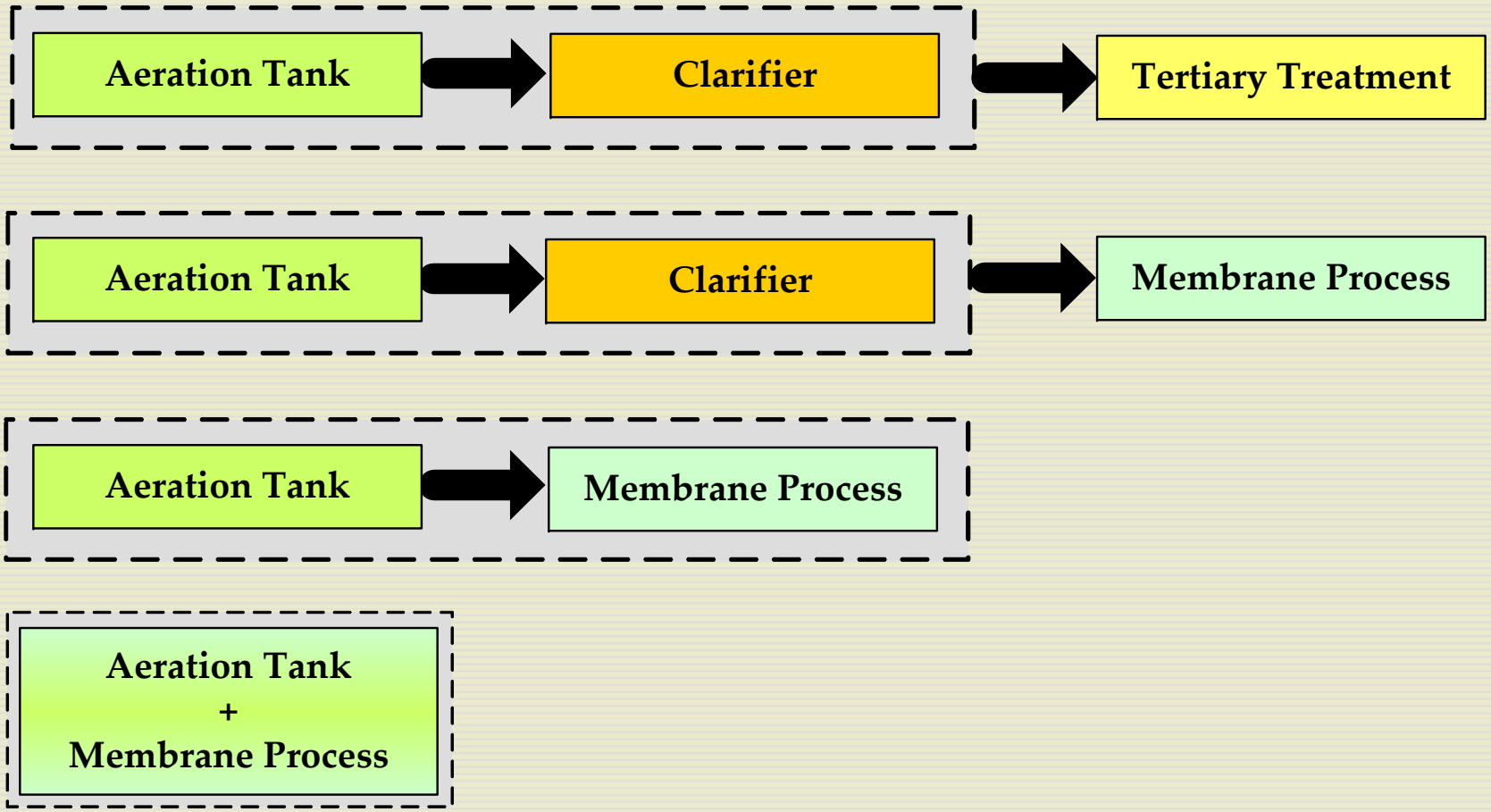
Membrane Bioreactors

the combination of membrane separation technology and activated sludge process

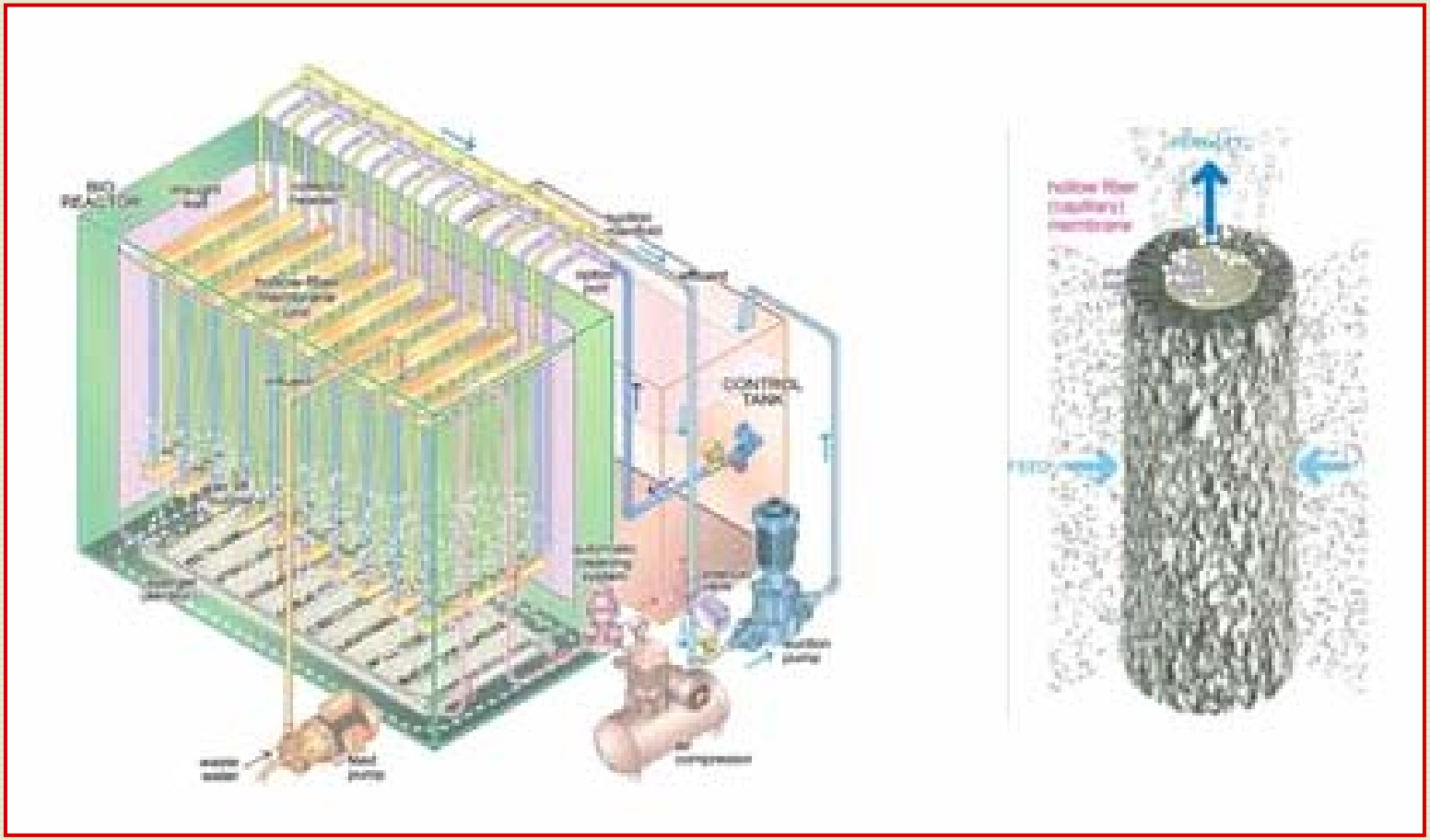
- ✓ has been developed since 1997 with **Dr. I G. Wenten**.
  - this research was funded by the Ministry of Research and Technology, Republik Indonesia, through RUT in 1998 – 2000.
  - This research has received an RUT AWARD from the Government of Republik Indonesia on August 11th 2003 in recognition of the work.

- ✓ this technology employs a mixed-culture of aerobic microorganisms.
- ✓ it is a wastewater treatment technology which has expanded rapidly in the last **5** years.
- ✓ however, its application in Indonesia is still limited.

✓ A Schematic comparison between conventional and membrane bioreactor systems



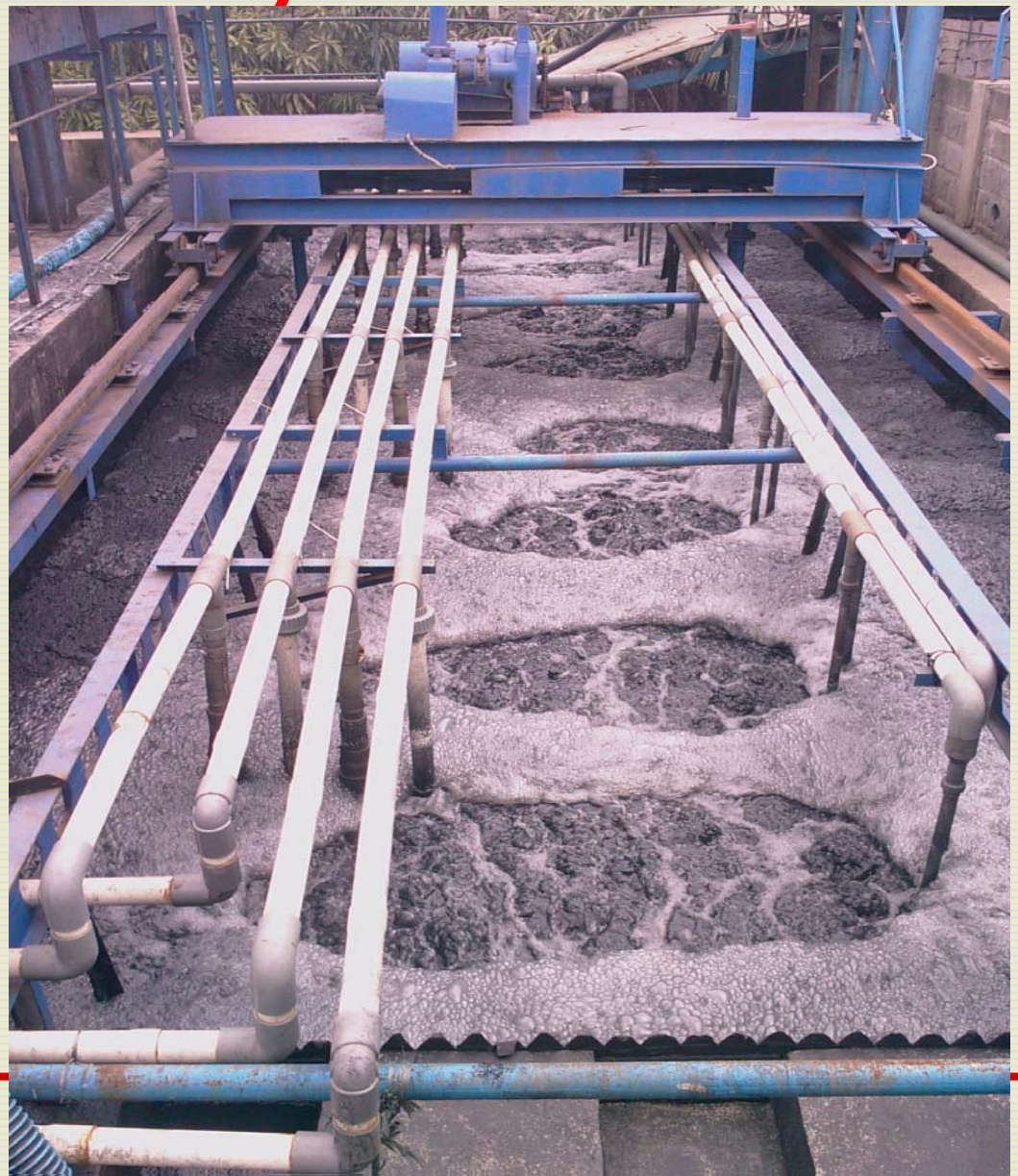
✓ Membrane Bioreactor Configuration

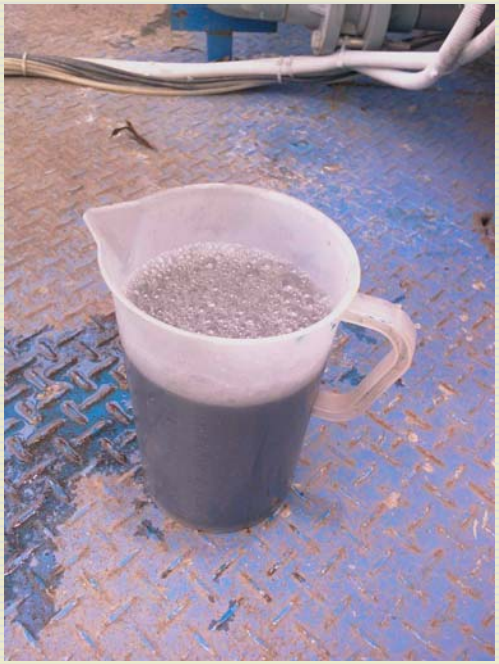


Source : Wenten (2005)

- ✓ the advantages of membrane bioreactor are :
  - require a small area, only 25 % compared to conventional system,
  - high quality of treated wastewater, allowing to recycle, and
  - small amount of sludge production.
- ✓ this technology is still being developed by **our institution**, and
- ✓ it is predicted that membrane bioreactors will replace the conventional system in the next **3 - 5** years.
- ✓ A number of shopping mall/industries in Jakarta and Bandung are already applying this technology.With the **purpose of water recycling**

Application of MBR in a Textile Mills (40 m^3/hour)





Inlet MBR

Outle MBR

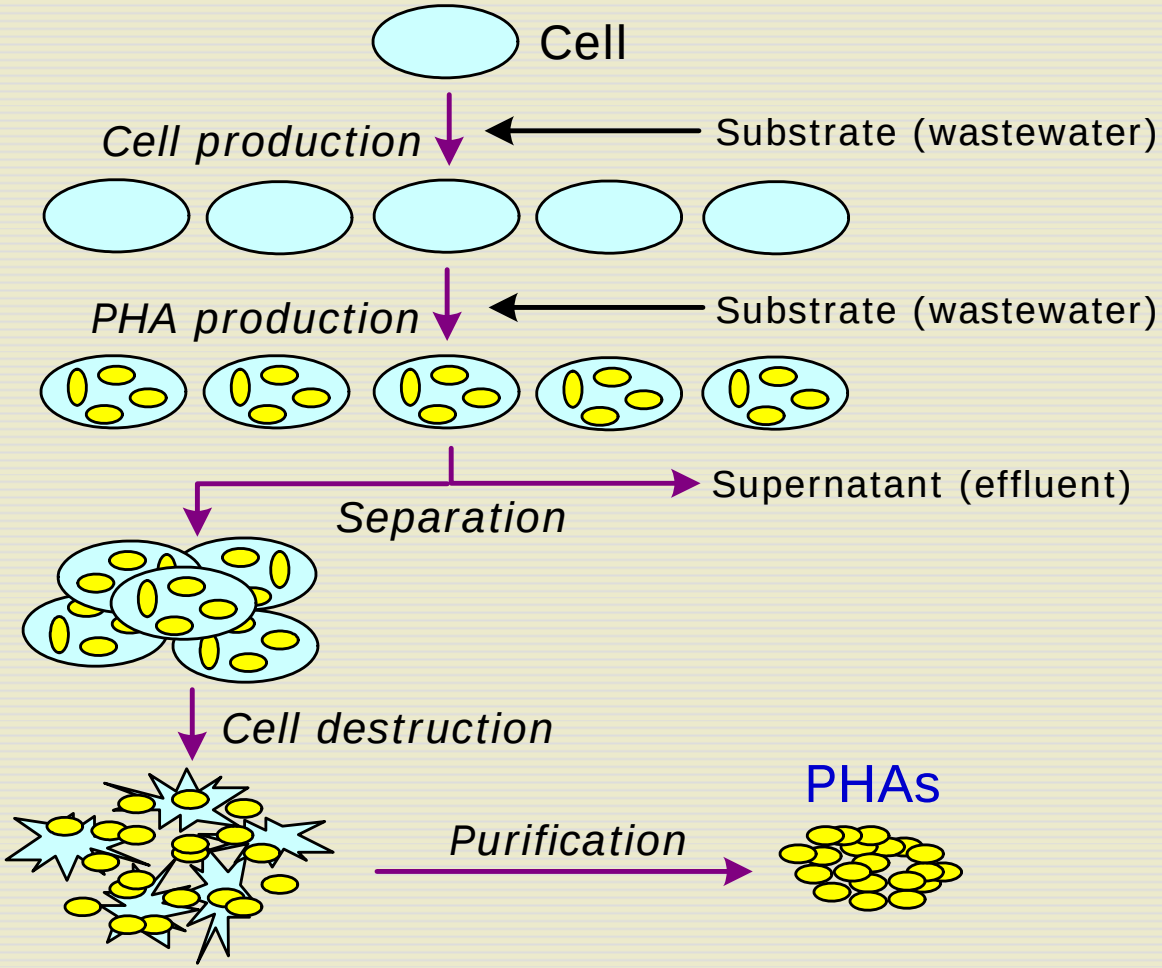
Production of biodegradable plastic Polyhydroxyalkanoates (PHAs)

- ✓ It was started 7 years ago.
- ✓ Funded by the Ministry of Research and Technology, Indonesia, through RUT 2003 – 2005.
- ✓ the aim of this research is to develop a plastic which can be degraded naturally in a relatively short time, but its strength is relatively the same as petrochemical plastics.

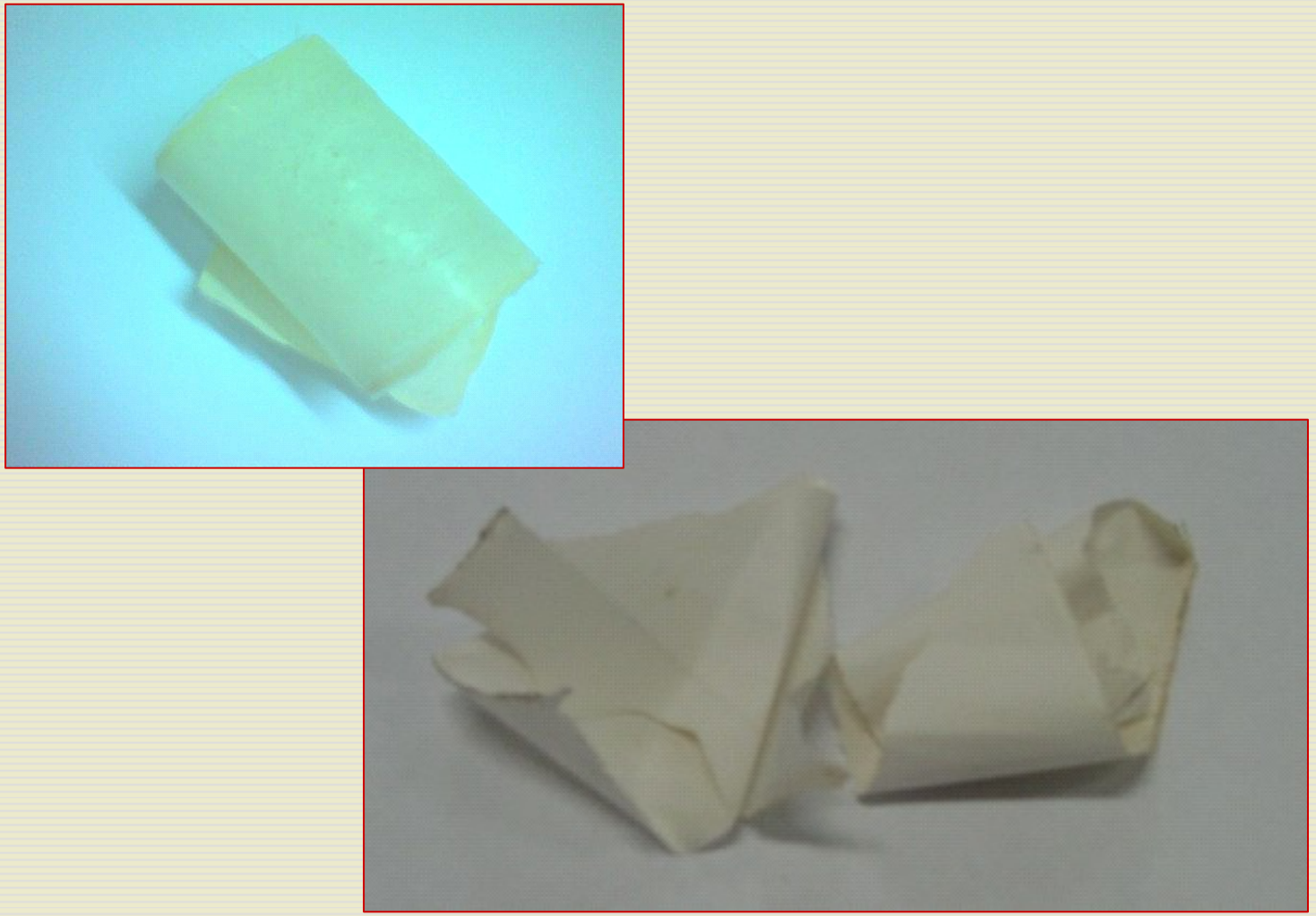
- ✓ the Production of PHA is conducted through an environmentally-modified microorganisms (pure and mixed cultures).
  - agro-industries wastewater is used as the substrate containing relatively high carbohydrate.
  - the purpose of this research is to make use of wastewater for producing eco-friendly products.

- ✓ the Biodegradability parameter has been tested, and it shows that the PHA is easier to degrade in a medium of river water and soil.

✓ the Schematic diagram of PHA production



- ✓ an Example of PHA plastic produced from tapioca wastewater using mixed-culture



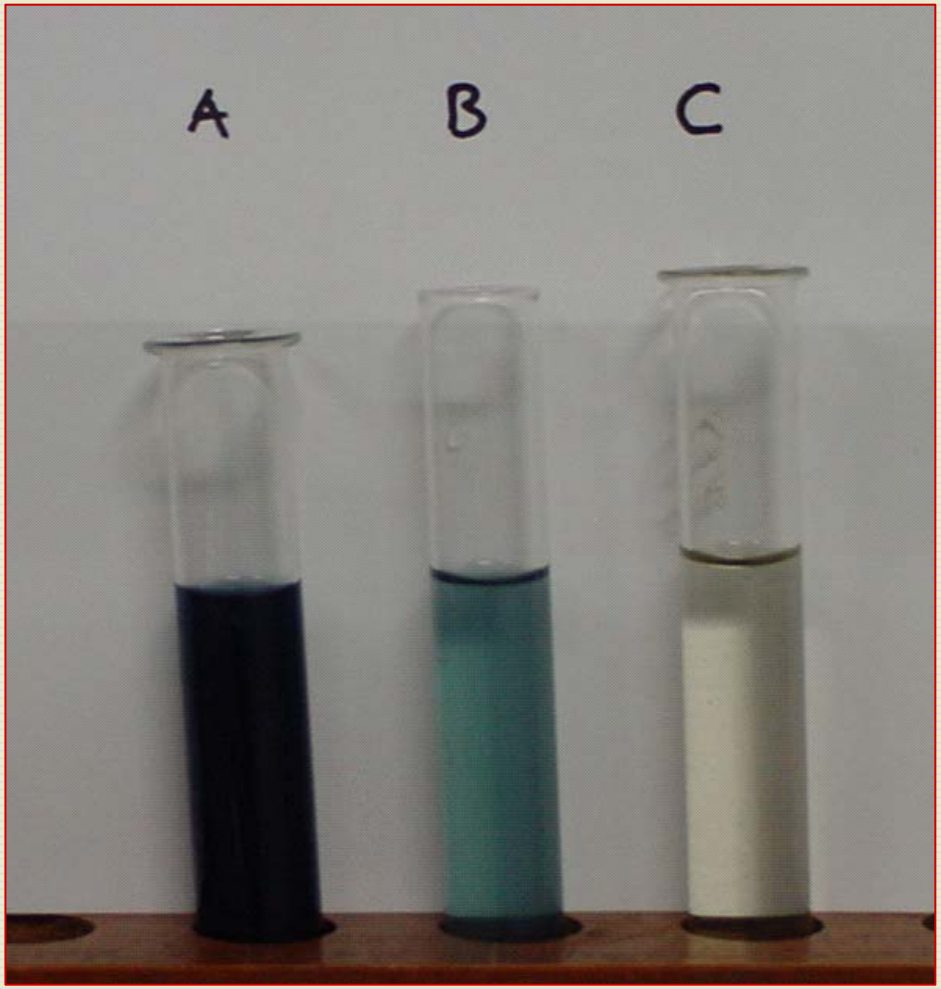
Color removal using eco-friendly technology

- ✓ Color has a complex structure and it is hard to degrade by microorganisms.
- ✓ Besides, the biodegradable substitutes for coloring agents are relatively limited. However the effort for developing those substitutes is still carried-out.
- ✓ At this moment, the most proven technology for color removal is a chemical treatment, through a flocculation-coagulation process which produces a sludge waste, or a chemical-oxidation process which requires a specialty chemicals or a relatively high energy cost.

- ✓ Since 1996, the anaerobic process has been studied using mixed-culture microorganisms for color removal.
  - the research was conducted at TU Delft, Netherland, funded by ESA-UNET (European Southeast Asian - University Network), 1996.
  - then it was funded by ASAHI GLASS Foundation in 1998 – 1999.

- ✓ Based on the results obtained from laboratory scale, this technology was applied to a textile industry producing denim fabrics at the flow rate of 20 m^3/hr of wastewater.

- ✓ an Example of untreated and treated wastewater from anaerobic-aerobic treatment.



(A) *untreated wastewater*
(B) *effluent from anaerobic*
(C) *effluent from aerobic*

- ✓ the research for color removal is still carried out using *white rot fungi* (Mycotreatment) with collaboratives work :
  - **Dr. Sri Harjati Suhardi** and **Dr. Wardono Niloperbowo** of Life Science Research Centre ITB,
  - and supported by **Prof. Bley** of TU Dresden, Germany.
- ✓ It is expected that this technology will be able to overcome the drawback of anaerobic process.
- ✓ This technology is **appropriate for a small textile mills.**

MYCOTREATMENT

- White rot fungi → able to degrade dye
  - *Trametes hirsuta*, *Trameter versicolor*
  - *Phanerochaete chrysosporium*
  - *Marasmius* sp.

Biocatalysts for dye degradation: extracellular enzymes:

- Lignin peroksidase
- Mangan peroksidase
- Laccase

Trametes hirsuta

Trameter versicolor

P. chrysosporium

Inert Media for Fungi Immobilization

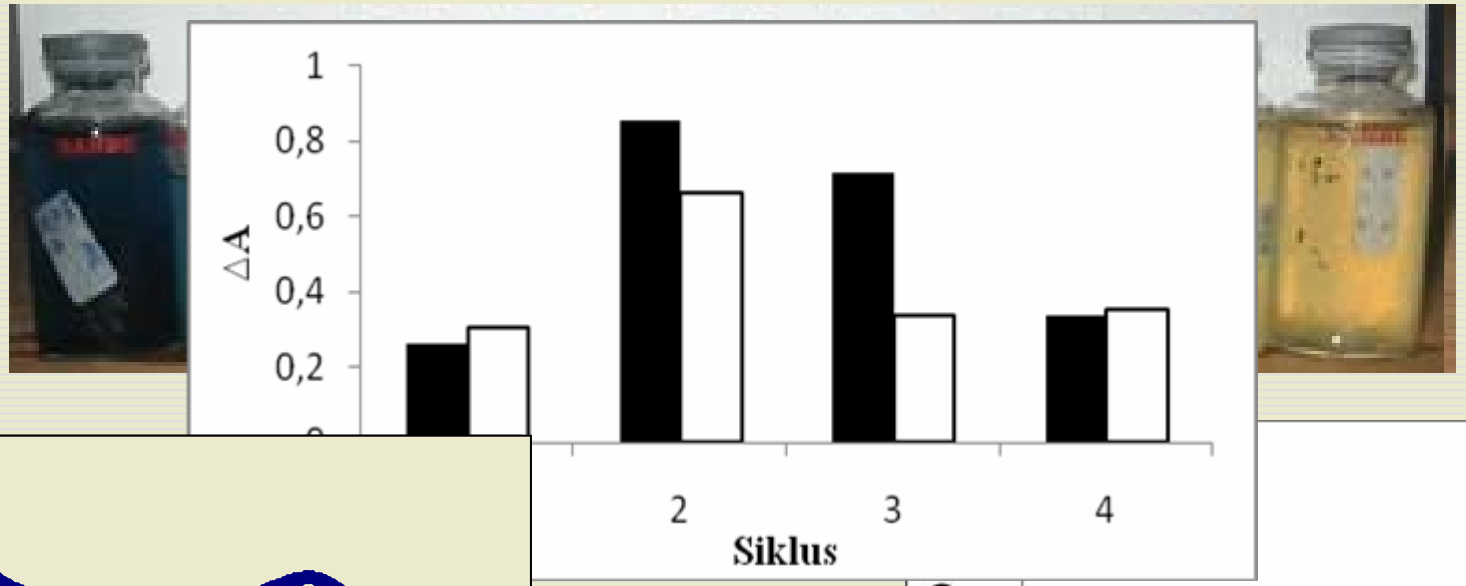
luffa

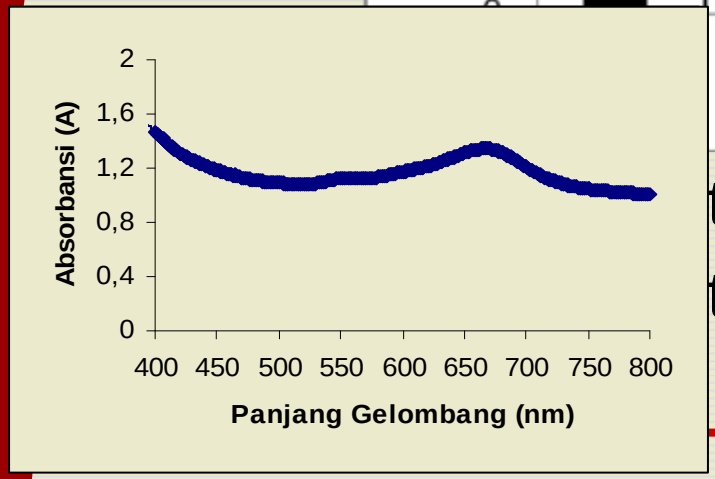
Marasmius sp. grown on *luffa*

Result Decrease in color

Indigo Carmine

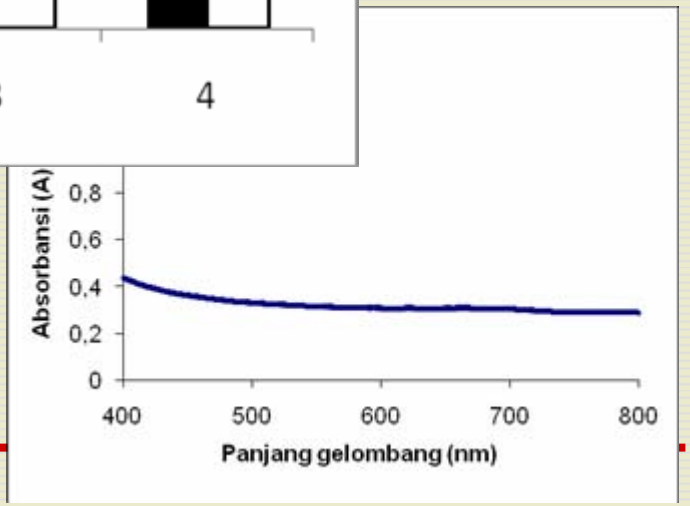
30’





te immersion

te immersion



Application of anaerobic processes for treatment of industrial wastewater

✓ several advantages of anaerobic process are :

- less energy requirement,
- waste sludge is only 10 % compared to aerobic process,
- produce biogas which can be used as an alternative energy source, and
- its potential to be used in the budgeting structure of CDM (*clean development mechanisms*).

- ✓ the researches on anaerobic process were funded by :
  - **RUT** in 1993 – 1995 (as a co-researcher),
  - **Osaka Gas Foundation** in 1996 – 1997, and
  - **RUT VII** in 2002 – 2004 (as a co-researcher).

- ✓ Several case studies that had been developed were wastewater treatments in oleochemical and “energy-drink” industries.

✓ Case study in Oleochemical Industry

Laboratory Scale

200 L
Pilot Scale

700 and 1,500 m3
industrial scale

✓ Case study in energy-drink industry

Original condition :

wastewater was treated aerobically

Current condition :

- increase in capacity (Three times),

- wastewater is treated anaerobically and aerobically

THE CHALLENGES

- Although the application of anaerobic processes are common in certain applications (industries), however this process is still applied rather 'primitively'. such as in the agroindustries throughout Indonesia.

- The application of anaerobic processes as energy generators.

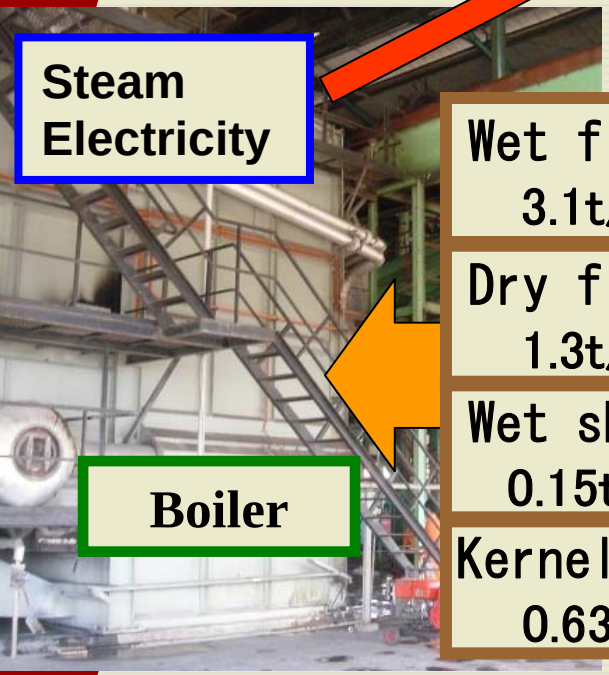
Material flow in Palm Oil Mill (The CHALLENGE)

Palm：25t/h

POM

Product:6.04t/h
CPO:5.45t/h
Kernel oil:0.59t/h

Steam
Electricity



Boiler

Wet fiber
3.1t/h

Dry fiber
1.3t/h

Wet shell
0.15t/h

Kernel cake
0.63t/h

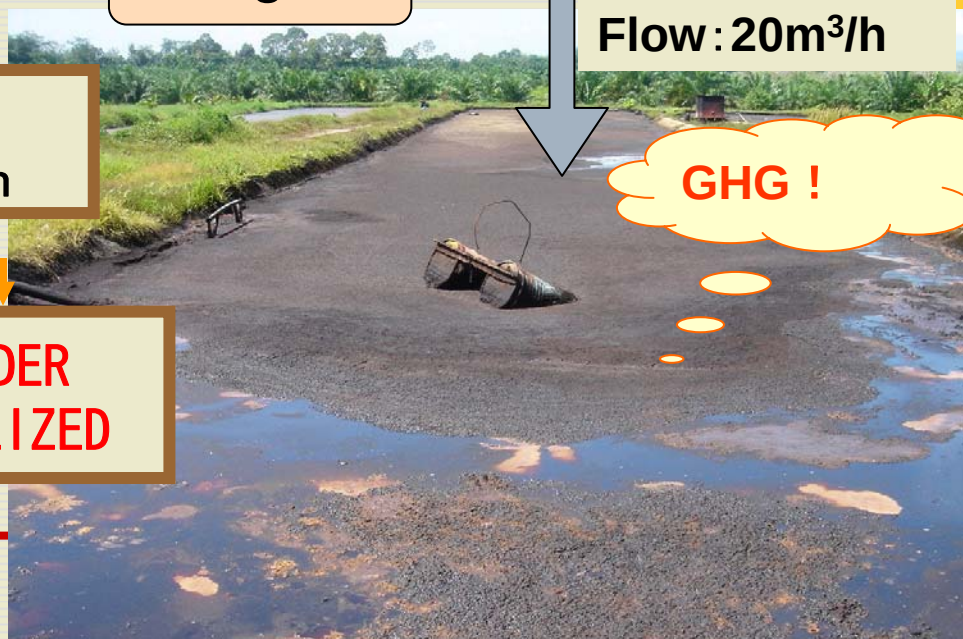
EFB
5.4t/h

UNDER
UTILIZED

225kg-C/h

COD：30000g/m³

Flow：20m³/h



GHG！

Thank You