INNOVATIVE WASTEWATER TREATMENT PROCESS FOR EASTERN COASTAL AREA

Dr.-Ing. Marius Mohr

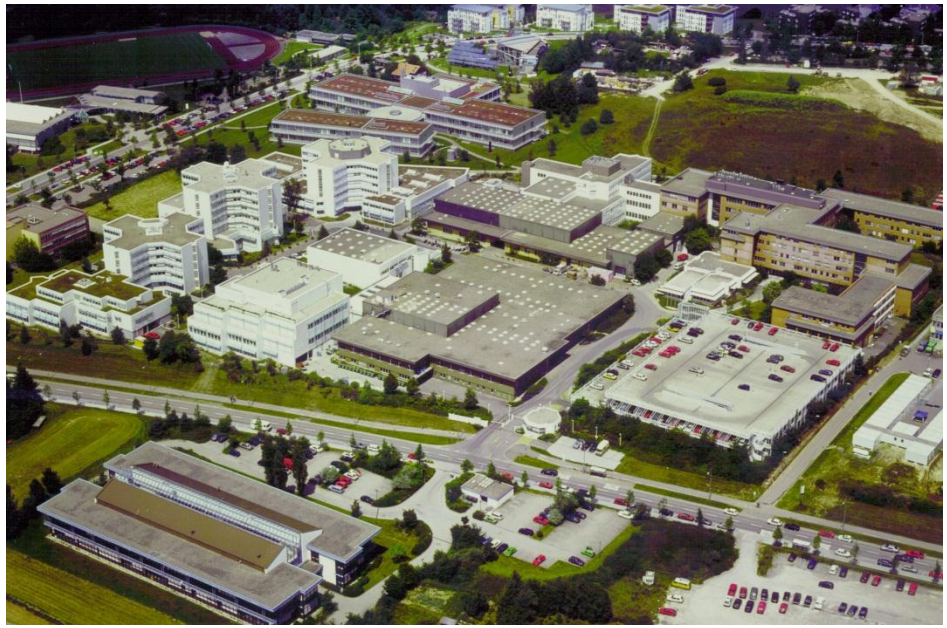
Regional Workshop on Integrated Resource Management in Asian Cities: The Urban Nexus

Da Nang, Vietnam, 25 June 2014

Fraunhofer IGB

Fraunhofer

- The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society
- Fraunhofer is the largest organization for applied research in Europe
- International collaboration through representative offices in Europe, the US, Asia and the Middle East

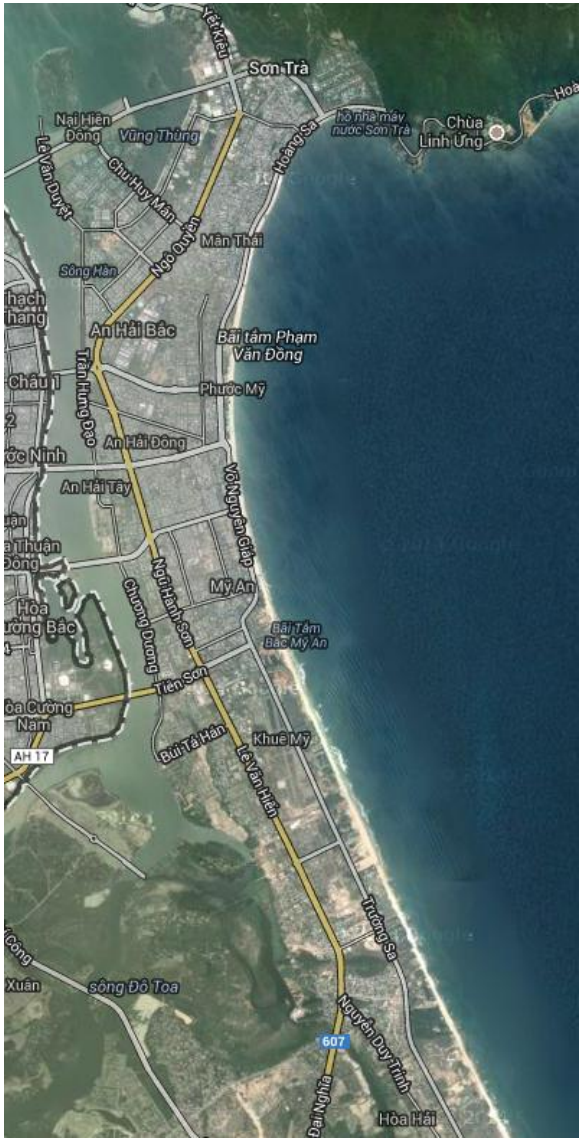


Outline

1. Situation in Da Nang, Eastern Coastal Area
2. Proposed solution for Eastern Coastal Area
3. Spotlights from other Nexus cities

Eastern Coastal Area (ECA)

- Son Tra Peninsula, population: 200,000 (Da Nang: 1 Mio.)
- Beautiful coastline, tourist hotels and resorts
- Most houses have septic tanks (infiltrate into ground)
- Some are connected to drainage system, some not (connection rate Da Nang: about 16%)
- Wastewater from septic tanks is overflowing into stormwater drainage system
- During heavy rain: overflow to the beaches
- Urban agriculture on unused plots
- Population is expected to increase strongly (urbanization)



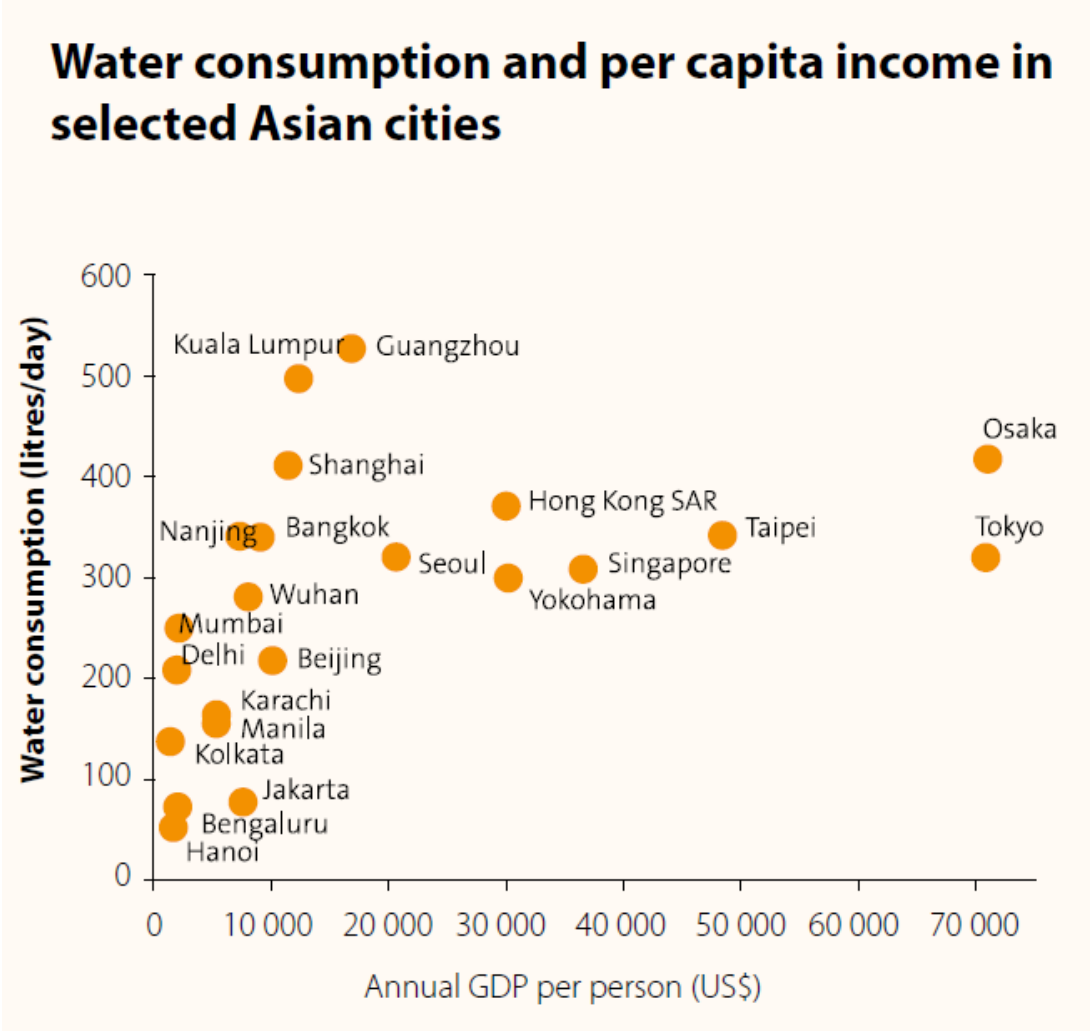
Source: Google Maps

Fraunhofer IGB

Drivers for wastewater concept

- Clean beaches and water
- Water scarcity during dry season, seawater intrusion
- Flooding from heavy rains, increasing sea level, river
- Increasing energy demand
- Image as an eco-friendly city

Increasing water demand



- Da Nang, GDP 2009: 1500 US$ per person; water consumption 2013: 130 l/cap/d
- Da Nang, GDP 2009: annual growth rate 12 %

Source: The United Nations World Water Development Report 2014

Framework conditions for wastewater concept

- Separate sewer system (wastewater and rainwater collected in separate systems)
  - No fecal bacteria in overflow nor in flood water
  - Wastewater treatment works during rainy season as well
- Economically feasible
- Limited space available (e.g. no pond system)
- Wastewater reuse and utilization of nutrients as fertilizer
- Utilization of energy potential (biogas production)

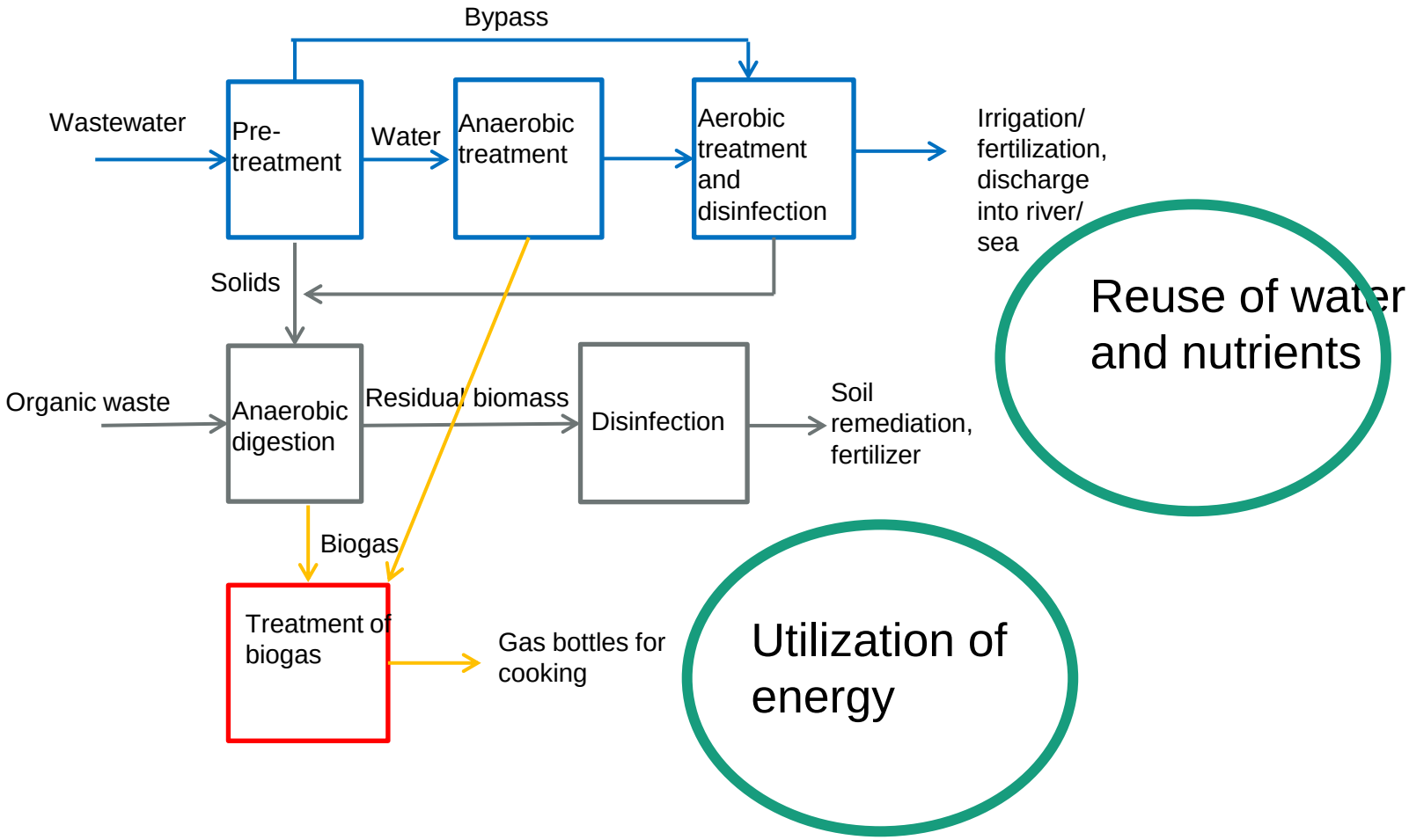
Content of wastewater

- **Organic matter:** used by microorganisms as substrate, can be transformed into biogas by anaerobic processes
- **Nutrients** (mainly nitrogen and phosphorous): can be used as fertilizer, in natural water bodies they lead to eutrophication (e.g. algae growth)
- **Microorganisms:** Mainly from human feces, some are pathogenic, can lead to diseases (e.g. in drinking water, agricultural products, bathing water)
- **Water:** can be reused if treated correctly

Wastewater reuse in agriculture: Milan San Rocco, Italy

- In operation since 2004
- Treating wastewater of 1 Mio. population equivalents
- Disinfection of water by sand filtration and UV
- Water used for irrigation of rice, corn, grass and horticulture
- Investment cost: 180 US$/ population equivalent
- Operation and maintenance cost: 0.156 US$/$m^3$, energy cost: 42 % of O&M-cost
- Reduction of energy costs through anaerobic digestion and utilization of nutrients with recycled water possible

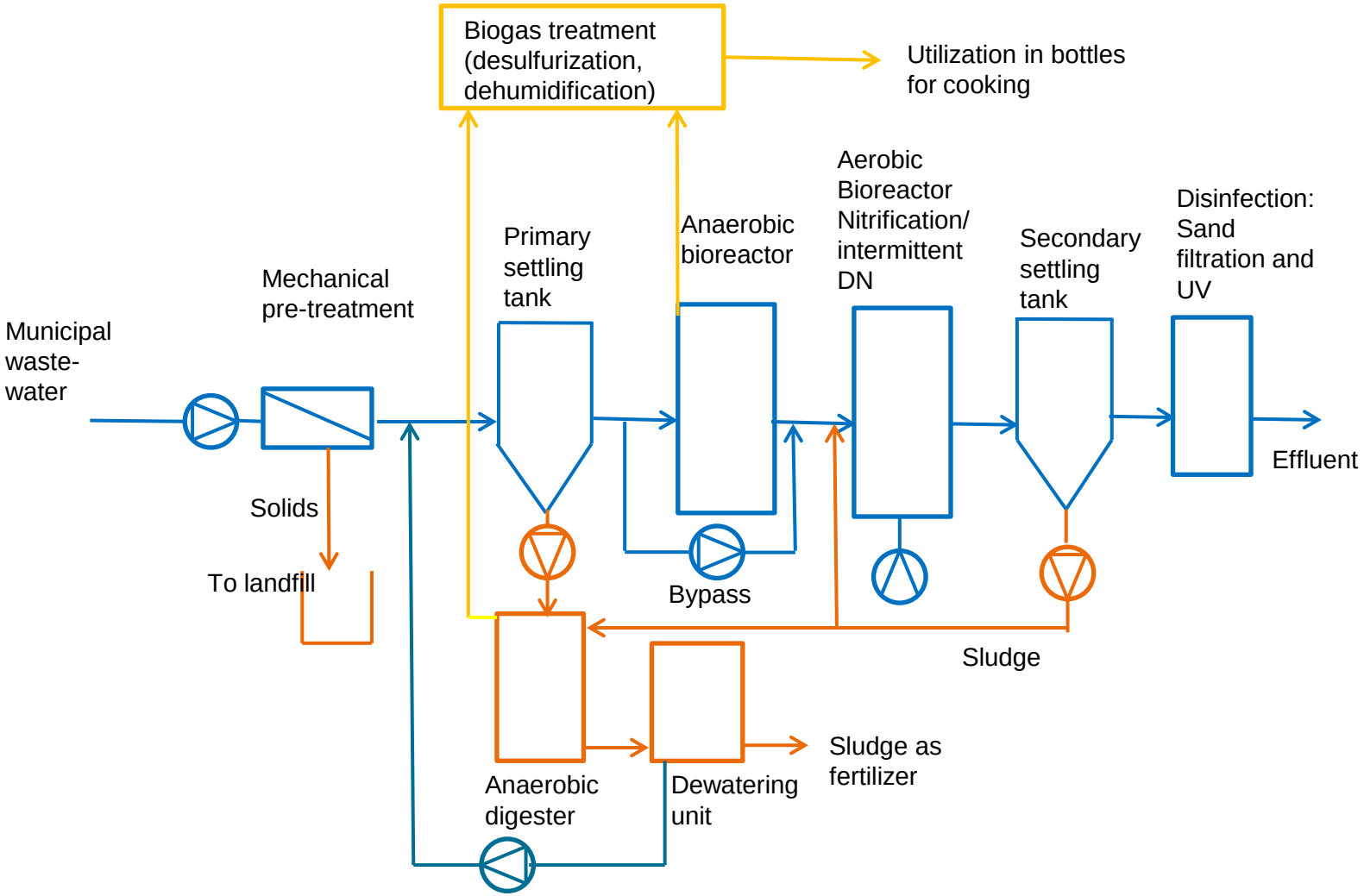
Wastewater treatment concept Da Nang, ECA



Approach for Da Nang, Eastern Coastal Area

- First step: pilot vacuum sewer system for 110 households
- Wastewater treatment in this small scale not economical
- Next step: connection of more households to vacuum sewer system
- Combine with wastewater treatment plant
- Example designed for 30,000 inhabitants (4,000 m^3/d)
- Gain experience as foundation for design of WWTPs for rest of peninsula

Design of WWTP for 30,000 population equivalents (p.e.)



Fraunhofer IGB

Two operation modes

- Mode 1: Dry season, demand for irrigation water and nutrients (N and P). Nutrients are not eliminated in treatment process.

⇒ Less consumption of chemicals for precipitation, organic load can be transformed into biogas. Nutrients are used as fertilizer.

- Mode 2: Rainy season, no demand for irrigation, treated wastewater is discharged into Han River. According to Vietnamese legislation, nutrient concentrations have to be reduced.

⇒ Phosphorous precipitation and denitrification of nitrate becomes necessary. Denitrification process needs organic load, less biogas produced.

Costs and benefits for WWTP for 30,000 p.e.

- Investment: 7 – 13 Mio. US$ (230-430 US$/cap) -depending on site conditions
- Area demand: ca. 6,000 m^2
- Operation: ca. 500,000 US$/a (0.345 US$/m^3)
- Biogas production from wastewater: ca. 1,200 m^3/d (mode 1), 850 m^3/d (mode 2)
- Income if sold as bottled gas (can be used instead of LPG): 30,000 US$/month (mode 1) or 20,500 US$/month (mode 2)

Costs and benefits for WWTP for 30,000 p.e.

- Energy demand for cooking in Hyatt Regency Da Nang Resort nearly covered by produced biogas
- If rainy season lasts 4 months: income of 320,000 US$/a from biogas
- Operation costs reduced to 180,000 US$/a (0.126 US$/m^3)
- Irrigation and fertilization of 100-200 ha possible, NPK-fertilizer worth 30,000 US$/a substituted

Kitchen waste

- Kitchen waste from hotels and resorts (3,000 kg/day) added to anaerobic digester
- If bio-waste from households is added to wastewater treatment, revenues through biogas increase strongly
- With higher amount of biogas (5 to 10 times more), utilization as fuel (e.g. for buses) becomes viable – option for large scale treatment plants
- Large hotels and resorts: check if individual decentralized wastewater treatment is more economic (option for reusing water on own grounds and using biogas themselves)

Strategic considerations

- Wastewater treatment capacity can be build up step by step to prevent high financial burdens
- As a large, densely populated town, Da Nang needs modern wastewater disposal with low space requirements for its further development
- To start with basic low-cost technology and later replace it by modern technology will be more expensive in the end
- Water scarcity is an issue during dry season- wastewater is available around the year
- 30% of demand on fruit and vegetables is met by urban agriculture in Da Nang- if groundwater is over-exploited, salt water intrudes

Increasing water demand

- With growing GDP, water demand increases
- Critical: a) secure water supply, b) treat wastewater (costs, capacity)
- Authorities can influence water demand:
  - Cost: step tariff – first 100 l/cap/d cheap, then increase price considerably
  - Awareness raising campaigns, teach in kindergartens and schools
  - Reducing water losses in supply network

Korat – biogas from bio-waste

- 400 t/d municipal solid waste of Korat and 28 other municipalities collected and brought to a landfill (in operation since 1999, sealed since 2008)
- April 2012: waste sorting plant and biogas plant start operation (built and operated by private company)
- Until now no regular operation of biogas plant possible- problems: sorting process and mixing of digesters
- Biogas used in Combined Heat and Power Plant (electricity and heat)
- Heat cannot be used on site, more than 50% of energy is wasted if producing electricity - utilization of gas as fuel for trucks to be considered
- German student currently analyzing process in Korat in frame of Nexus project (supervision by GIZ and Fraunhofer IGB)
- Incineration plant is envisaged to reduce amount of waste for landfill

Korat biogas plant

Korat – wastewater collection and treatment

- Around 90 % of population connected to combined sewer system
- Most houses have septic tanks - solids retained, water overflows to sewer system
- Pond system for wastewater treatment since 1990‘s (3 x 3 ponds)
- Since 2009, Activated Sludge (AS) process for effluent of ponds (3 plants)
- Effluent used for irrigation in urban agriculture off the record
- Wastewater reaching pond system is very “thin“ due to degradation in septic tanks (methane emission)
- Further degradation in ponds, not much left for AS-plants
- Recommendation: treat wastewater directly in AS-plant and use area of ponds for alternative purposes.
- Last pond in each line: maturation pond, utilization of treated wastewater for irrigation (and fertilization) – officially and regulated!

Korat – wastewater treatment

Ulan Bator- heat in wastewater has large potential

- Mean temperature of -2 °C: “coldest capital in the world”
- High demand on energy for heating of buildings: centralized district heating system exists
- Centralized WWTP: wastewater has high temperatures in relation to air temperature in cold season (originating from use of warm water in flats and from industrial wastewater)
- Utilization of heat in treated wastewater: potential of around 500,000 MWh per year- 17,000 (not insulated) to 40,000 (insulated) flats (60 m^2) can be heated throughout the year
- Use of heat in wastewater also possible in sewer close to users (decentralized solution), e.g. to pre-heat water for warm water generation – heat exchanger in sewer, pump, heat exchanger in cold water line

Ulan Bator central WWTP

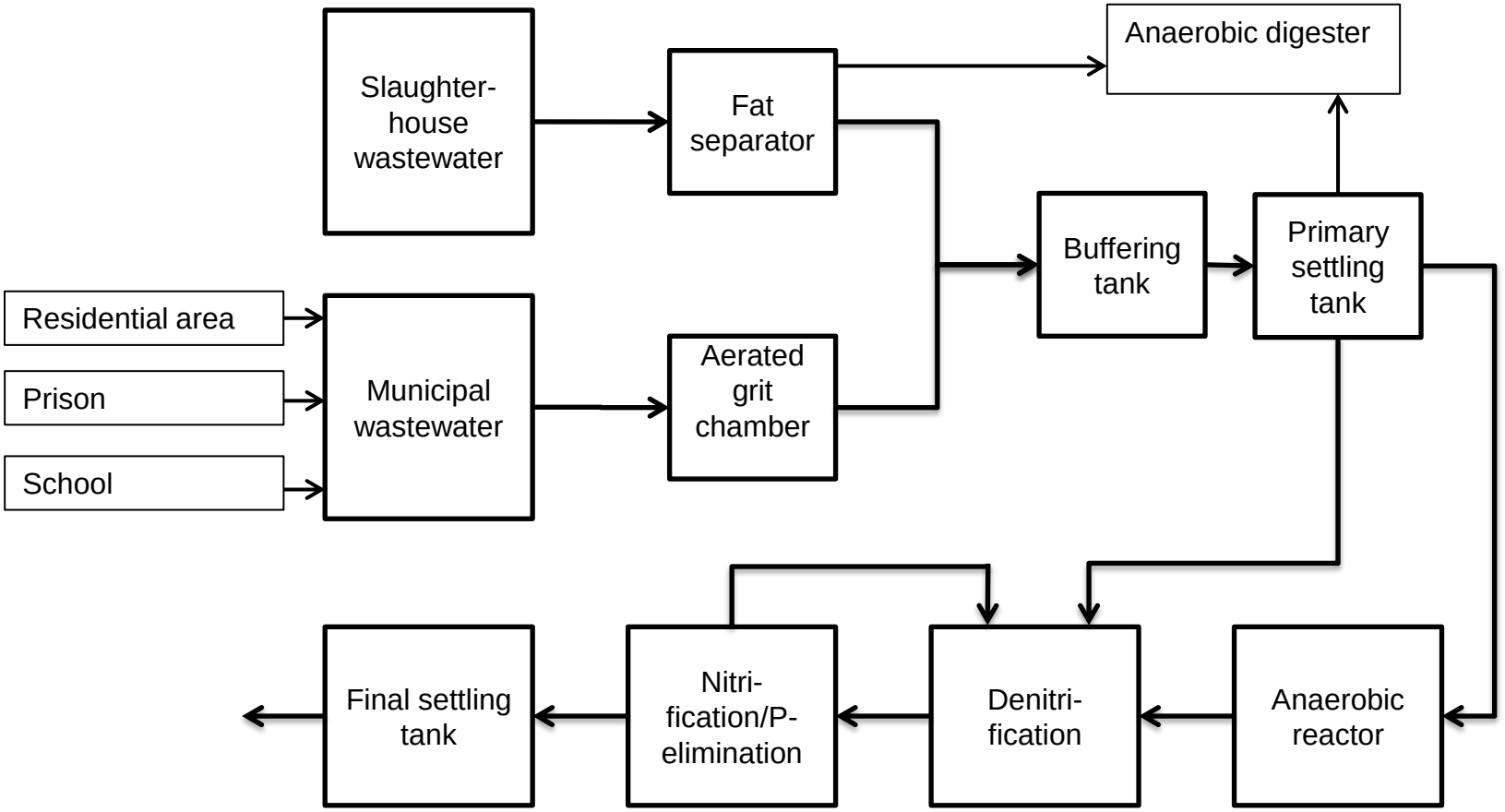
Fraunhofer IGB

Naga City- pilot wastewater plant

- No wastewater treatment facilities exist yet, septic tanks under houses
- Treatment of wastewater from a low-cost residential area, a prison, a slaughterhouse and a school in one plant (around 210 m^3/d)
- Treated water can be discharged into creek
- Biogas generation for processes in slaughterhouse
- If successfully piloted, treatment process can be applied for other parts of Naga step by step
- Objective 1: improve water quality in Naga River and Bicol River, flowing through the center of the city, and thus improve quality of living
- Objective 2: Increase share of renewable energy used

Thank you for your attention!

Wastewater treatment process Del Rosario, Naga



Fraunhofer IGB