BLUE PLAINS - WASHINGTON DC

NUTRIENT & ENERGY RECOVERY FACILITY

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Introduction

We have been recognized as a profession that protects the environment and public health. We are now beginning to be recognized as resource stewards, needing to recover and utilize valuable and important resources as well.
WATER RESOURCE RECOVERY FACILITY

OUR VISION

CLEAN WATER –
PROCESSES TO REMOVE ORGANICS & NUTRIENTS FROM THE EXCESS WATER DISTRIBUTED FOR COMMUNITY USE & PRODUCE CLEAN EFFLUENT AND CLEAN RIVERS.

ENERGY –
PROCESSES TO GENERATE ELECTRICITY FOR THE LARGEST USER OF POWER IN WASHINGTON DC. AND REDUCE POWER CONSUMPTION

NUTRIENTS –
BENEFITS OF RECYCLING RECOVERED NUTRIENTS & ORGANICS AS A RESOURCE FOR SUSTAINABLE WORLD AGRONOMIC PRODUCTION
Clean (RIVER) Water

Conventional Nitrification-Denitrification

**Nitrogen Removal**

**Nitritation**

- Autotrophic Bacteria
  - Aerobic Environment
  - 1 mole Nitrate (NO₃⁻)
    - 25% O₂ (energy)
  - 1 mole Nitrite (NO₂⁻)
    - 75% O₂ (energy)
    - ~100% Alkalinity
  - 1 mole Ammonia (NH₃ / NH₄⁺)

**Denitrification**

- Heterotrophic Bacteria
  - Anaerobic Environment
  - 40% Carbon (BOD)
  - 60% Carbon (BOD)
  - 1 mole Nitrate (NO₃⁻)
    - 85% Carbon (BOD)
  - ½ mole Nitrogen Gas (N₂)

**Phosphorus Removal**

- Nitrification
- Denitrification
- SOLIDS REMOVAL
- NITROGEN REMOVAL
- PHOSPHORUS REMOVAL
- CBOD REMOVAL

**IT'S ALL ABOUT THE SOLIDS**
Sustainable Agriculture

SUSTAINABLE FOOD NUTRIENTS

SILVICULTURE FERTILIZATION

SUSTAINABLE MICRONUTRIENT SOURCE

N,P,K - NUTRIENT MANAGEMENT

SOURCE OF ORGANICS

RENEWABLE NUTRIENT SOURCE

URBAN PLANTS

PASTURE Management

dc water is life
Energy Recovery

RENEWABLE ENERGY SOURCE
Gas Production

RENEWABLE SOLIDS SOURCE

Carbon Sequestration & Nutrient Reuse

Electricity from Digester Gas

Reduced Fossil Fuel CO2 EMMISIONS REDUCTION

PHOTOVOLTAICS

dc water is life
NUTRIENT & ENERGY RECOVERY
1937 ➔ 2015

ENGINEERING NEWS-RECORD
March 29, 1937

Sewage Disposal
For the Nation’s Capital

Construction work has been practically completed on the 185 mgd. sewage plant that will provide reclamation for all the sewage to the District of Columbia that is now passing untreated into the Potomac River. The new plant, to be placed in operation this spring, includes such features as ozone separation, sludge digestion, and gas of electric generation, and treatment of the sludge for use as fertilizer. The project is costing about $10,000,000 and has been financed with a PWA loan and 30 per cent grant. The design of the plant was predicated on an investigation of the sewage disposal problem of the District of Columbia by a team of engineers, composed of Harrison E. Whaley, Howard F. Cregney, and the late John H. Gregory.

Sewage of the district is collected in combined sewers and it has been pumped directly into the Potomac River through two submersed outlets. During the river flows the river channel and outlets are carefully controlled to avoid devastations from Math, Virginia, and the water at Alexandria being poll- luted. The headworks includes that to maintain 50 per cent separation of dis- solved sewage in the river against a dilution of about 7.5.

Pollution of the Potomac River will be greatly lessened when the 185 mgd. primary sewage treatment and sludge digestion plant for the District of Columbia goes into operation this spring.

By Frank A. Marion

By Frank A. Marion

A survey made by the U.S. Public Health Service in 1933 showed an average bacterial pollution of 200,000 per c.c. at Fort Point, which is almost half way below the present sewer discharges. Some de- cent is bacteria exists farther down the river, but a survey by the Public Health Service in 1933-34 would indicate that they exist in considerable numbers at least 50 miles from the naval yard.

Treatment recommendations

As a result of these investigations the board of sanitary engineers recom- mended (1) that a reclamation process be used during the six cold months of the year and (2) the adoption of the anaerobic type of treatment to provide a high degree of purification during the remaining months. These plans approach the first step recommendation of their recommendation.

The plant will handle the discharge

Photo by McFerren Bros., Baltimore
FIG. 2—LAYOUT of the 130 m.g.d. District of Columbia sedimentation and separate sludge digestion disposal plant. Below, a recent aerial view.
CLEAN WATER
NUTRIENT RECOVERY FACILITY 2015

Largest Advance Recovery System in the World

370MGD WATER

Largest user of power in DC
PUMPING - ENERGY CONSUMED

9 % of ENERGY USED

UP TO 540 MGD FLOW PUMPED 2X

27 Pumps up to 100 MGD -> 1.2 Billion Gallon Per Day Capacity
4% ENERGY CONSUMPTION - Removal Of Solids by Settling
35% of CBOD – 50% TSS
Ferric Chloride & Anionic Polymer Added
SECONDARY REACTORS

REMOVE CBOD
By Aerobic Microbial Respiration
Ferric Chloride Added For Phosphorus Removal

6 TWO STAGE CENTRIFICAL COMPRESSION BLOWERS USE 14% OF TOTAL ENERGY CONSUMPTION FOR AERATION

FINE BUBBLE DIFFUSESERS LOWERS ENERGY USE
TESTING MICROBIAL ELECTROCHEMICAL CELLS TO REDUCE ENERGY CONSUMPTION FOR AERATION
NITRIFICATION / DENITRIFICATION BASINS

Removal of Nitrogen From Water - Convert To $\text{N}_2$ Gas

Possible reduction of 20% of electrical use for aeration

Nitrification to reduce methanol addition for denitrification
Multimedia Filters

10% of total energy consumption
Sand and Anthracite (coal/carbon) filtration removes Total Suspended Solids (TSS) from effluent water – final polishing
Chlorination to eliminate Ecoli bacteria
Electricity Consumption at Blue Plains

CURRENT TOTAL CONSUMPTION 27-30 MW

- Nitrification Aeration: 20%
- Secondary Sedimentation + RAS: 7%
- Nitrification Sedimentation + RAS: 7%
- Filter Pumping: 5%
- Filtration: 10%
- Solids Handling: 14%
- Chlorination: <1%
- COF & CMF: 5%
- Misc: 10%
- Primary Treatment: 4%
- Secondary Aeration: 14%
- Pumping & Preliminary Treatment: 4%

Source: PCS data supplemented with estimates

Fast Fact:
Over 1MW of installed lighting capacity at Blue Plains alone!
Energy Recovery

Sustainable Energy Source

Digester Gas Production

Reduced Fossil Fuel CO2 Emissions Reduction

Carbon Sequestration & Nutrient Reuse

Electricity from Digester Gas

Photovoltaics
TOTAL CBOD REMOVAL

Carbonaceous Biochemical Oxygen Demand

mg/liter

Influent Avg
CBOD
Daily Outfall
Monthly Permit Level (5.0)
Monthly Average

TOTAL CBOD REMOVAL

DATE - MONTH - YEAR
Zero Net Energy Facility

THROUGH

Innovation

POWER PRODUCTION AND ENERGY COST REDUCTIONS
ENERGY REDUCTION & RECOVERY

- BLUE PLAINS - LARGEST D.C. ELECTRICAL USER
- GOAL TO NET ZERO – $1.1 – $1.4 MILLION MONTHLY ELECTRIC BILL REDUCTION (Strass, Austria Facility is NET ZERO ENERGY)
- DIGESTION = %40 REDUCTION IN FUEL COSTS - NUTRIENT DISTRIBUTION TO FARM LAND
- DIGESTION = GAS TURBINES - 8 TO 13 MW OF POWER
- “UTILIZE CARBON”- REDUCE DEPENDENCE ON FOSSIL FUELS
- SUSTAINABLE ENERGY SOURCES
- UTILIZE MULTIPLE RENEWABLE FORMS OF ENERGY
LOW HANGING FRUIT

- Thermal Hydrolysis - over 15 Years
- Digestion – Methane Production
- Combined Heat and Power – CHP
- Recuperative Turbines
- Photovoltaic's
- Annamox
- CoDigestion
- Thermal Heat Recovery
- Hydrogen Production? Proven – Pilot Ready?
INNOVATION For GAS Production

Gravity Thickeners

DAFTs

13 MW Power

Emissions

Emergency Flares

Combined Heat and Power (CHP)

Steam

Biogas

1

2

3

4

5

6

Pre-Dewatering

Thermal Hydrolysis

Mesophilic Anaerobic Digestion

Final Dewatering

Recycle Processing

Load out to farms

Dewatering

Mixer

Store & Load out

Lime

INNOVATION For GAS Production
Anaerobic Digestion = Methane Gas Production

- Energy from the chemical bonds of organic matter
- 9,300,000 Btu/metric ton of biosolids
- Available through anaerobic digestion
RECUPERATIVE GAS TURBINES
Gas Turbine Technology Overview

- Gas to air recuperative which increases efficiency and reduces air emissions
- Exhaust can be used to generate process steam
- No pre- or post-combustion emission controls required to meet CA BACT (LAER)
ENERGY FROM THE DIGESTER GAS

- Digester Gas (methane) collected is fed to a Combined Heat and Power (CHP) system.
- 3 Gas turbines, burn Digester Gas & generate electricity (up to 13 MW, enough to power 8000 homes).
- Heat generated by the turbine is stripped off with a Heart Recovery Steam Generator (HRSG) unit.
- The turbine generates enough excess heat to bring the TH and Digestion process up to temperature.
Energy Production from Co-Digestion Toward Energy Neutrality

East Bay MUD (Calif) now sells power to the Grid, with a new 4.6 MW gas turbine on-line, it is the 1st water/ww utility in the US to produce more power than it uses.

Having excess digester capacity available,

EBMUD has operated like a business to allow fats, greases, and various food and beverage wastes to be trucked in and co-digested at the plant.
Energy Efficient Bacteria: Annamox
Deammonification (simplified)

Partial Nitritation-Anammox = “Deammonification”

- 63% reduction in Oxygen demand
- Almost 100% reduction in Carbon demand
- 80% reduction in Biomass production
- Reduced CO₂ emissions (4.7 - 0.7 ton CO₂/ton N)

ANAMMOX: “Anaerobic” Ammonia Oxidation
PHOTOVOLTAICS

PLANNING FUTURE POWER SOURCE - UP TO 11 MW
Array Locations for Blue Plains
Nutrient Rebate Research Projects

$2/wt rebated through biosolids contracts. DC Water is obligated to spend it on research

Virginia Tech

- Class A Blended Soil Products
- Cambi Class A Agricultural Certification

University of Maryland + USDA

- Thermal Hydrolysis of Trace Organics
- Odor Modeling and Prevention
- Cambi Class A Pathogen Certification
- Degradation Triclosan, Triclocarban

University of Maryland + NRL

- Microbial Electrochemical Cells
MICROBIAL ELECTROCHEMICAL CELLS

• RESEARCH BY U of MD, NAVAL RESEARCH LABORATORY & DCWATER

• EVALUATING SEDIMENT/BENTHIC MICROBIAL CELLS -
  • Generating Power from Organic Matter Oxidizing
  • Future work to Evaluate N Removal & H₂ generation
The VISION for Microbial Reactors & Hydrogen Generation

Only 25% of the Carbonaceous Volatile Solids are Now Utilized By Digestion

Expending Energy to Reduce Carbon / Volatile Solids - Energy Capture
Capital Improvement Projects Underway

**INNOVATION**

- **New Centrate Treatment Process**
  - $84 million

- **BP Tunnel Dewatering Pump Station & Enhanced Clarification Facility**
  - $300 million

- **Upgrade & expansion of the Nit/Denit system**
  - $26 million

- **Dual Purpose Sed Basins Upgrade**
  - $18 million

- **New Biosolids Management Program**
  - $450 million

- **Enhanced Nutrient Removal Facilities**
  - $340 million

**Upgrade & expansion of the Nit/Denit system**
Sustainable Food Nutrients & Energy Resources

Animal Consumption of Grain, Hay and Pasture

Agricultural Products Transported to City

Nutrients / Biosolids Transported to Land Application

Products Nutrients

Recycling of:
- Phosphorus
- Nitrogen
- Organic Matter
- Zinc and other micronutrients

Nutrient Consumption

Urban Nutrients Flows to Treatment Facility

Power

Nutrient Removal & Power Facility

Crops Fertilized

Nutrients / Biosolids Transported to Land Application
WASTES

Resources Out of Place