

SEWAGE EFFLUENT: What's known about MARINE SYSTEMS, RECLAIMING EFFLUENT FOR HUMAN USE, TECHNOLOGIES



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How I became concerned

Portland OR allows sewage hauler to recycle effluent for **beer**.¹

“Craft Brewers” more than 5,300 in the U.S.²

Lagunitas Brewing Company (CA) membrane bioreactor--uses an EcoVolt Membrane Bioreactor (MBR), an electrical process that promotes anaerobic digestion, to remove up to 90 percent of pollutants

California, Half Moon Bay Brewing Company experimented with making its Mavericks Tunnel Vision IPA using gray water (from sinks, showers and washing machines), which it treated with the same technology used by NASA

2017, Stone Brewing of Escondido, California, produced five barrels of Full Circle Pale Ale from the city of San Diego’s Pure Water Facility, which treats wastewater to drinking-water standards.

Clean Water Services operates the largest water treatment program in Oregon. In 2014, it launched a pilot project called Pure Water Brew that provided highly treated water to Oregon Brew Crew,

Arizona, the Pima County Regional Wastewater Reclamation Department is working with the Arizona Craft Brewers Guild, Denver-area breweries to make the first craft beer with recycled water in Colorado.

States promote effluent for **potable water**.

E.G. In 2007, the Orange County Water District in Southern California opened a plant that treats sewage with traditional microfiltration, then further cleanses it with reverse osmosis, and disinfects it with ultraviolet light and peroxide. Governor Brown now wants all of CA to consider it for potable water.

WA State passed a rule allowing the effluent to be recycled for food crops, recreational lands, wetlands and, case by case, potable water.³

EFFLUENT WATER

- Marine systems
- Plant uptake
- Treatments

Marine Habitat

ATTENTION

Secondary treated domestic wastewater discharge site due East of this sign, size is approximately 400 m North, 400 m South and 100 m East.

Certain activities, such as swimming and the harvesting of shellfish for RAW consumption are prohibited.

Additional information can be obtained by calling the Public Works Department at 224-4058 7:00am - 4:00pm Monday through Friday.

City of Seward

The Harvest of Kelp is

PROHIBITED

**In all waters of the
North Gulf Coast**

GENERAL STATEMENTS

- **The silencing of the seas: how our oceans are going quiet.**
 - About one-third of the CO₂ that humans emit into the atmosphere dissolves in the ocean, leading to seawater acidity.
 - Affects ability to create calcium carbonate shell or skeletons (such as corals, some plankton, and snails)
 - [alters the behaviour](#) of many animals by messing up their [brain functioning](#) like sound reception and those ocean ecosystems produce.
- **Sampling the inhabitants of a stream tells us much about that stream and its landscape.**

Differences between urban and rural streams. Biological diversity is higher upstream of WWTPs; year-to-year variation at the same places is low.
- **Scientists have only tested a fraction of pharmaceuticals for their effects on marine life, and most remain unregulated in wastewater.**



- **Good News: Congress banned plastic microbeads in skin care products**
 - “Many water treatment plants cannot filter out the tiny plastics, allowing them to flow into the ocean or waterways where fish could mistake them for food. By the time the plastic gets downstream [towards the ocean](#), they become these toxic pills,” he told CBS News last year.” Big fish eat little fish, eventually the fish is on your dinner plate. “And you're eating that fish with all the toxins it consumed along the way.” Marcus Eriksen, a science educator and research director of the environmental group 5 Gyres

International

Atlantic Ocean: Over 70% of deep-sea fish have ingested plastic.⁶

Indonesia: anthropogenic debris was found in 28% of individual fish and in 55% of all species. It was all **plastics**.⁷

USA: anthropogenic debris found in 25% of individual fish and in 67% of all species, primarily **fibers**.

Anthropogenic debris was found in 33% of individual shellfish sampled.⁷

São Paulo, Brazil: animals around the sewage outfall appear to feel the **drug effects**. Ibuprofen, common painkiller, and triclosan, an antibacterial compound found in products including toothpastes and body washes caused a range of negative effects, including malformed membranes and reproductive difficulties.⁸

Montreal: Plasticizers BEHP, BEHTP, and BEHA found in significant quantities in influents, process streams, treated effluent and solid residues of a large treatment plant.⁹

EUROPE

- Increased Levels of **Multiresistant Bacteria and Resistance Genes** after Wastewater Treatment and Their Dissemination into **Lake Geneva, Switzerland**.¹⁰
- Hospital sewage contained the highest load of **MRB and ARGs**. Wastewater treatment reduced the total bacterial load up to 78%, but evidence for selection of extremely multiresistant strains and accumulation of resistance genes was observed.

U.S. STATES

- **AZ₁₁**
- **Pathogen Distribution in an Effluent-Dominated Stream**
 - **E. coli** numbers increased with distance from the discharge point, contrary to what might be expected from bacteria die-off.
 - once **E. coli** are introduced and established in the environment, in-situ growth can elevate counts in an affected water supply to levels above what is expected from local sources.
- **HI₁₂**
- **Study: Several Common Drugs Could Leach Into Oahu's Groundwater**
- Agencies tested for and found **62 CECs** in Wahiawa Wastewater Treatment Plant effluent, Kaukonahua Stream – receiving effluent via Lake Wilson, and waters in Haleiwa.
- The Ninth U.S. Circuit Court of Appeals ruled in favor of environmental groups challenging the **County of Maui's** decades-old **practice injecting partially treated WWTP effluent into wells**. The wells leaked & wastewater migrated through groundwater to the ocean. The court held the county liable for discharges into jurisdictional waters. An EPA tracer dye study confirmed **64 percent of the effluent wound up in the ocean less than three months after injection into the wells.**¹³

GREAT LAKES AREA

- **GREAT LAKES WATERWAYS**¹⁴
- Hormone-disrupting compounds – called **alkylphenols** - making it through wastewater treatment plants and contaminating rivers and fish in the **Great Lakes and Upper MS regions**.
- **Mercury & PCBs** still problems
- **MI River regions.** A Canadian study tested **28 sites in lakes Erie, Huron and Ontario**, and found **alkylphenols** distributed widely in sediments in the lower Great Lakes, with concentrations higher in sediments near larger cities.
- **Duluth-Superior Harbor: Tertiary-treated** municipal wastewater significant point source of **antibiotic resistance genes**
- **MS River: Triclosan**, a widely used antimicrobial, transformed in river to 2,8-DCDD. Three other **dioxin congeners**, 2,3,7-TCDD, 1,2,8-TriCDD, and 1,2,3,8-TCDD were also found. (The contribution of triclosan-derived dioxins to the total dioxin pool increased as high as 31% by mass in recent years.)
- **MN: antibiotics commonly used in healthcare and animal health** in lakes, rivers, and streams throughout Minnesota; the U.S. Geological Survey found antibiotics in groundwater in non-agricultural and urban areas. Groundwater is used for drinking by many people, especially in rural areas. ¹⁵

OHIO₁₆

- **Northwest Ohio: PPCP's** in the environment, influent, effluent and biosolids from three Class B facilities wastewater treatment facilities in, and a stream containing effluent discharge from a rural treatment facility were analyzed. Twenty compounds including several classes of antibiotics, acidic pharmaceuticals, and prescribed medications were analyzed.
- **Effluent** waters contained elevated levels of **carbamazepine** (epilepsy and neuropathic pain), **clindamycin** (bacterial infections) and **sulfamethoxazole** (infections: urinary tract, middle ear and bronchitis, traveler's diarrhea, and shigellosis (bacillary dysentery)).

WA State

- Wastewater influent, secondary effluent, tertiary effluent, and biosolids were sampled. Four of the five WWTPs discharge within the **Puget Sound** watershed. Two provide secondary treatment, and three tertiary treatment for nitrogen and phosphorus removal. Two produce tertiary-treated reclaimed water. ¹⁷
- **Three PPCPs (carbamazepine – seizure control, fluoxetine, and thiabendazole) were relatively untreated by the WWTP technologies.**
- The Washington State Department of Ecology conducted a **PPCP** product study in the **Sequim-Dungeness area**. Water quality samples from WWTP effluent, surface water, and groundwater tested for 24 chemicals. **17 PPCPs were detected in the effluent, 4 were detected in surface water, and 3 were detected in groundwater .**
- **Flame retardant-contaminated dust** attaches to clothing, washes out in the laundry, making way to WWTPs. Some of these chemicals are not removed during treatment and are discharged directly to waterways – hundreds of pounds per year from a single treatment plant.¹⁸
 - estimates a yearly discharge of 174 kilograms, or 384 pounds, of the three Tris flame retardants to the **Columbia River**—from just one treatment plant; the equivalent of the flame retardant used to treat 1088 couches.
 - Estimate a total of more than one million pounds end up in waterways nationally each year.
- Feds paying for sewer analysis of **pot** usage in Washington (Results not released yet)¹⁹

What's In the Fish ?

- Scientists have found evidence of **antidepressant drugs** in the **brain tissue of 10 different species of fish** in the **Great Lakes** region.²⁰
- **Puget Sound** fish in general **have three to five times higher levels of certain contaminants — PCBs, flame retardants** — than other salmon populations up and down the coast.
A **neurotoxin** in the water causes them to lose equilibrium.²¹
- **From Prozac to caffeine to cholesterol medicine, from ibuprofen to bug spray**, researchers found an alphabet soup of drugs and other personal-care products in sewage-treatment wastewater and in the tissue of **juvenile chinook** in Puget Sound.²²
- **Victoria, Canada: Pharmaceuticals and personal care products (PPCP) in molluscs** exposed to wastewater.... resident **Northern Horse mussels** collected near one of the major sewage outfalls showed high concentrations of the **antimicrobial triclosan, the antibiotic ciprofloxacin, and the antidepressant sertraline, among others**.²³
- 2017 Wastewater and Marine Environment Program for the Victoria region, showed that **shellfish, sediment, and water** in the region immediately around sewage outfalls show traces of **drugs**, including triclosan and ibuprofen and many more.⁸

RECLAIMING SEWAGE EFFLUENT



What Could This Mean for Health ?

- **More than 300 km³—yes, cubic kilometers—of municipal wastewater & more than 600 km³ of industrial wastewater, are generated world-wide annually. More on the way.**²⁴
- Only **8%** of domestic and industrial wastewater is treated in developing countries; **70%** in high-income countries.
- **13% of CA wastewater is reclaimed; 39% used for crop irrigation.**²⁵
- documentation of the presence of **antibiotic resistant bacteria and their genes** in the three byproducts of wastewater treatment plants: 1) biosolids/sewage sludge often used as a fertilizer and compost ; 2) **recycled water** for irrigating **leafy green crops** consumed raw as well as **grass in public parks** and other **playing fields** and for **potable water**; and 3) effluent that is discharged to lakes, rivers, and oceans.²⁶

Soybean Plants

- --**Carbamazepine** (med for seizure control), **triclosan**, and **triclocarban** found concentrated in root tissues and translocated into above ground parts, including the beans.²⁷
- --Some accumulation and translocation for **antihistamine and Prozac/antidepressant**.

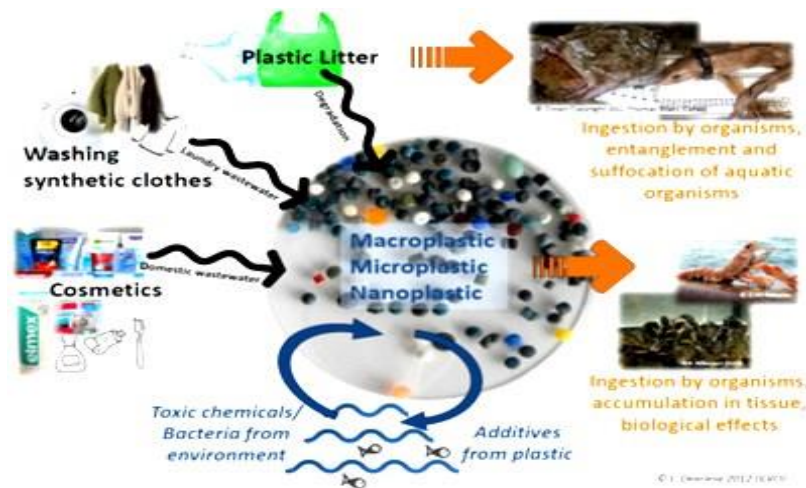
RW : More Food for Thought

Wastewater Irrigation on Farms Contaminates Food: Treated Wastewater Irrigation: **Uptake of Pharmaceutical and Personal Care Products by Common Vegetables** under Field Conditions₂₈

- Measured levels of 19 commonly occurring **PPCPs in 8 vegetables**
- **64% of vegetables irrigated with tertiary treated wastewater contained traces of CECs**, including DEET (a repellent) and triclosan (an antibacterial), caffeine, meprobamate, primidone, DEET, carbamazepine, dilantin, naproxen, and triclosan.
- Billions of people globally drink **water** contaminated by **plastic particles**;
- -- **83% of samples polluted.**₂₉
- **US**: highest contamination rate at **94%** -- **plastic fibres in tap water** sampled including at Congress buildings, the US EPA headquarters, and Trump Tower in New York. Lebanon and India had the next highest rates.
- **UK, Germany and France: 72%**

MICROPLASTICS – Food & Beverage

- **Principal concerns:**
- **Microplastics contain and absorb toxic chemicals from sewage;** WWTP don't always filter or trap these. In the nanometre range they can penetrate a cell meaning organs.²⁹



- Research on wild animals shows they are released in the body
- **U.K.:** found in 1/3 of fish caught
 - **Germany:** fibres and fragments in all 24 **beer** brands tested, and **honey and sugar**.
 - **Paris:** microplastic **falls from air** - 3-10 tons annually—on the city and found in homes;
 - **Beirut, Lebanon:** **94%** of sampled **natural springs** contaminated

Microplastics cont'd

- **Microplasticplastic particles**, not captured by WWTPs, released via effluent into freshwater systems were found **inside fish from Lake Winnipeg**.³⁰
- **Carp** had an average of **seven microplastic particles**, **sauger** had an average of one in their gastrointestinal tracts.
- **Microplastics found in supermarket fish, shellfish**³¹

TREATMENT CLAIMS

- **Extraction - Tapping sewage for useful materials**
- Commercial products that could be made from municipal liquid waste include phosphorus, nitrogen-rich fertilizers, fuels, biodegradable plastics, thickeners for paints and other products, and oils for making a range of chemical intermediates.
- Netherlands leads the push to extract products from wastewater. It has programs to recover energy, phosphorus, and cellulose. Cellulose as a feedstock for biofuels or higher-value industrial chemicals. Removing cellulose can also cut the energy consumed in conventional sludge treatment by up to 40%.³²
- **Electrochemistry:** low energy, cost-effective wastewater purification system treats water and wastewater without chemicals.³³
- --- **Treatment:** 1. pump wastewater into the system's chamber. 2. electric current is passed.
- --- **Result:** electrodes in the chamber generate hydrogen peroxide and hydroxyl radical (a very powerful oxidising agent) that reacts with the complex [organic compounds](#) in the water. The generated hydrogen peroxide and hydroxyl radical are completely used up during treatment and continuously break down the complex compounds into simpler molecules, until all organic contaminants have been degraded into water and carbon dioxide.
- Positives: •Can remove up to 99 per cent of **hard-to-treat organic compounds** not biodegradeable found in various types of industrial wastewater.
- system operates on low electrical power and does not generate secondary waste, such as sludge.

MEMBRANE

According to UW Professor Emeritus Mark Benjamin, the successful application of membranes to remove contaminants from water is arguably the biggest advance in water treatment since chlorination was introduced for disinfection more than 100 years ago. Yet, the technology's potential is far from realized largely due to the limitations imposed by membrane fouling; the plugging of membrane pores by contaminants that the membrane has captured.³⁴

- But a new process combines the deposition of a thin layer of heated aluminum oxide particles on a porous support surface and then passes the raw water through those particles and the support. The aluminum particles remove a very large portion of the foulants, so that when it is subsequently desalinated by reverse osmosis, the reverse osmosis system can be operated at higher fluxes for longer times and at lower pressures. Eventually, the pre-deposited particles become saturated and must be replaced with fresh ones.
- <https://cen.acs.org/articles/93/web/2015/01/Bacteria-Remain-Dormant-UV-Disinfection.html>

ULTRAVIOLET LIGHT

- **Bacteria May Remain Dormant After UV Disinfection**₃₅
- Many drinking water treatment facilities worldwide disinfect water with ultraviolet light. A new study shows that UV treatment alone can push **bacteria into a dormant state instead of killing them**, and in some cases, the bacteria can **later revive and proliferate** (*Environ. Sci.*

Sunlight for Rotavirus

- inhibition of viral RNA synthesis positively correlates with a loss of rotavirus infectivity.³⁶
- --- Wastewater collected from 3 sources: secondary effluent from a municipal WWTP, a wastewater pond of an animal farming facility & effluent from a pond system treating municipal wastewater. Used 5 different rotavirus strains (RVs).
- --- RVs had various susceptibilities to sunlight disinfection. E.G. human strains more susceptible to the endogenous inactivation than exogenous inactivation. Porcine RV more susceptible to exogenous inactivation.

TOILET TO TAP

- **Newly patented wastewater recycling system turns toilet water into purified drinking water**₃₇
- **Northeast Ohio: on-site drinkable water** recycling system for homes and small buildings in Moreland Hills.
 - **First Stage:** a multi-chambered system of containers where solids are removed and biological organisms decompose remaining microscopic contaminants.
 -
 - **Second Stage:** ultraviolet light and reverse-osmosis membranes filter and sterilize the water, removing microorganisms, chemicals, salts, pharmaceuticals and hygiene products,” resulting in drinking water of ultra-purity.”
 -
 - **Third Stage:** a 500- or 2,000-gallon storage tank where the purified water is chlorinated and held for everyday use

TAKE HOME MESSAGE: IF YOU DON'T LOOK, YOU DON'T FIND

Present treatments for human use do not guarantee safety

- Rule language not science based.
- Legislative language cited is years old; prior to much of the science on the hazards
- Very few wastewater constituents are assessed; most are unknown.
- WWTP pathogens like prions and anti-biotic resistant genes can not be treated and can multiply.
- Contaminants of emerging concern, ultrafine particulate matter, plastic fibers pass through treatment and remain in reclaimed waters
- Methods for “further treatment” – chlorination, UV light, ultraviolet light – are problematic. Chlorination leaves an unwanted byproduct in the water.
- Lacking are long term health studies
- Class A water may be cleaner than Class B, but it is far from clean or safe. Once a tertiary treatment facility is permitted, it requires no oversight.
- No reliable, foolproof method that creates safe potable water. Safer does not mean safe.
- Injecting reclaimed water into aquifers has a high probability of contaminating public drinking water systems.
- State codes used for this purpose seem to fit the purpose.
- Facilities regulate themselves. Government staffs are being cut; enforcement lacks.
- **We are all guinea pigs.**

SEWAGE WASTE DIRECTIONS



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