INFORMATION SHEET

INTRODUCTION TO WASTEWATER: NATURE, SOURCES OF GENERATION AND TREATMENT WITH A FOCUS ON SEWAGE

NOT ENSURING THAT OUR PLANET'S VITAL ELEMENTS AND MECHANISMS ARE MAINTAINED AND FREE OF CONTAMINATION IS EQUIVALENT TO DELIBERATELY COMMITTING SUICIDE, KILLING A GREAT NUMBER OF LIFE-FORMS IN THE PROCESS, INCLUDING HUMAN BEINGS.

SOURCES AND TYPES OF WATER CONTAMINATION

One drop of oil can make up to 25 liters of water unfit for drinking. *

NON-ORGANIC
(Chemical Products, plastics, …),
=
RECYCLING when possible

ORGANIC
(Faeces, urine)
=
ENERGY + NUTRIENTS
(Food for plants)

Industrial Wastewater

Wastewater which comes from industrial processes using various chemical components (factories, mining water, some intensive agricultural based industries and processing plants such as rubber factories, palm oil, coconut oil, and other crops; contains a wide range of contaminants and chemical compounds that may each require specific . treatment.

One gram of 2,4-D (a common household herbicide) can contaminate ten million litres of drinking water. *

Sewage: Human domestic wastewater

Wastewater that comes from human primary necessity activities (bodily excreta, cooking, washing and cleaning); it mainly contains nitrogenous compounds (proteins and urea), carbohydrates (sugars, starches and cellulose) and fats (soap, cooking oil and greases). Intense cooking activities as in a restaurant for example creates a type of water high in grease content which should have its own treatment before being mixed with sewage effluent (if at all). What is important to understand is the value of these so-called "waste" materials for the plant kingdom. Water from the toilet contains many potentially disease-causing bacteria but also higher levels of nutrients and is called **blackwater**. Water from the sink or shower usually contains fewer bacteria and a lower amount of nutrients and is called **greywater**.

Storm Water

Water which comes from the rain which has had contact with the ground surface. It can be close to clean water quality but can also be heavily contaminated, with sewage and organic and/or non-organic wastewaters if these mix with surface runoff water.

Surface Runoff

Wastewater of particular concern in urban environments: street litter, debris of household or commercial litter, lawn and garden litter, leaves, abrasives and chemicals used for various domestic tasks, oil and grease from motor vehicles. machinery and maintenance use, pesticides, herbicides and fertilisers, etc. .). It is often mixed with Storm Water, when not with Industrial, Commercial and Sewage wastewaters as is the case in many large urban sewage systems.

Agricultural industry + Animal farming

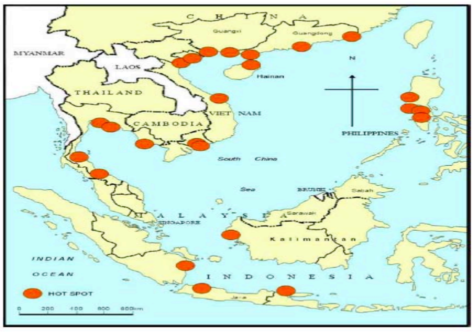
Wastewater which comes from all animal raising, maintenance and/or processing (production units): dairy farms, cattle ranches, sheep and goat farms, piggeries, duck and snake farms, seafood aquaculture, chicken batteries or hatcheries as well as birds such as ostriches, quails, etc. . Depending on the kind of activity and level of processing, it requires specific treatment or disposal.

One gram of PCBs can make up to one billion litres of water unsuitable for freshwater aquatic life. *

*** : Reference: Canadian government: Environment Canada : http://www.ec.gc.ca***

1. What are the effects of untreated wastewater?

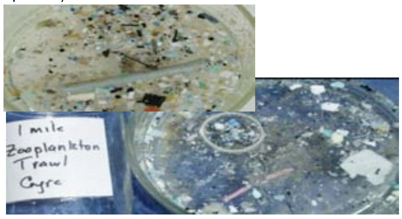
Untreated wastewater is the greatest cause in the world of the dispersion of disease-causing bacteria and the pollution of groundwater, rivers, lakes and other water bodies, disrupting ecosystems and creating a chain reaction of negative effects. In so-called developing countries, 85–95% of sewage is discharged directly into rivers, lakes, and coastal areas (UNFPA 2001; Bouwman et al. 2005), some of which are also used for water supply and bathing. Consequently, water-related diseases, such as diarrhea, cholera and amoebic dysentery, among others, claim millions of lives annually (WHO/UNICEF 2000). Because of these dangers, wastewater is often thought of as a "toxic" or unusable "waste" material. However, with an understanding of the materials in wastewater and the natural processes that purify them, wastewater can become a valuable resource.

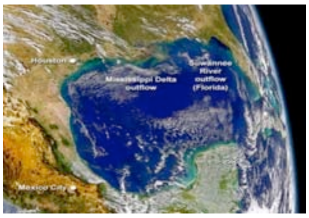


Marine pollution hotspots caused by sewage in South-East Asia (Courtesy: *OVERVIEW OF IMPACT OF SEWAGE ON THE MARINE ENVIRONMENT OF EAST ASIA: SOCIAL AND ECONOMIC OPPORTUNITIES, Chia Lin Sien, Institute of Asia-Pacific Studies, Graduate School of Asia-Pacific Studies, Japan. Assisted by George S. Akpan, Lloyd C. Onyirimba and Maribel B. Aguilos, UNITED NATIONS ENVIRONMENT PROGRAMME, EAST ASIAN SEAS REGIONAL COORDINATING UNIT, 2001).*

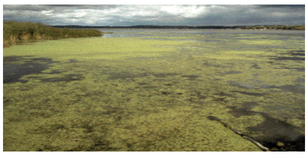
Death of fish (here in 2007, China)

ABOVE: Plastic in the ocean is increasingly found in the stomachs of Albatrosses. BELOW: plastic pellets in zooplankton, the base of the ocean's food chain (Courtesy Captain C. Moore "Seas of plastic").



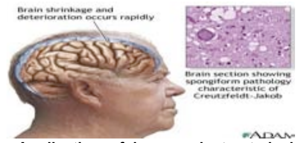


EUTROPHIZATION

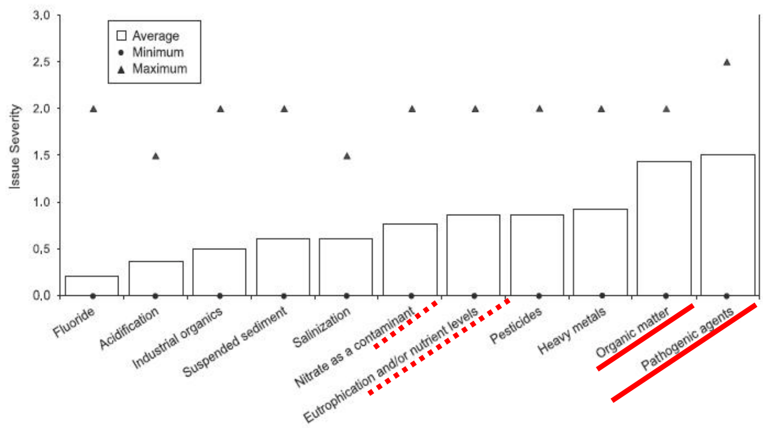


Excessive nutrients causing proliferation of aquatic vegetation) and causing « Dead» zones: Top Photo: USA. in the Golf of Mexico, 2004 (Credit: SeaWiFS Project, NASA Goddard, et Orbimage) **and Lake Champlain. Bottom photo : Tijuana Mexico**

Exposure to acid water and toxic heavy metals associated with disturbed acid sulfate soils cause infections such as Epizootic Ulcerative Syndrome (EUS) also known as 'red-spot' disease). Here a woman with heavy metal poisoning from repeated exposure to contaminated water, Philippines.



Above: Application of improperly treated sludge is held responsible for the dramatic spread of prions acting as transmissible agents of fatal Alzheimer's Disease (AD) and Creutzfeldt Jakob Disease (CJD) in humans, as well as scapie in sheep and goat and Mad Cow Disease (BSE), (Courtesy: Vernon Blogspot, 2010).

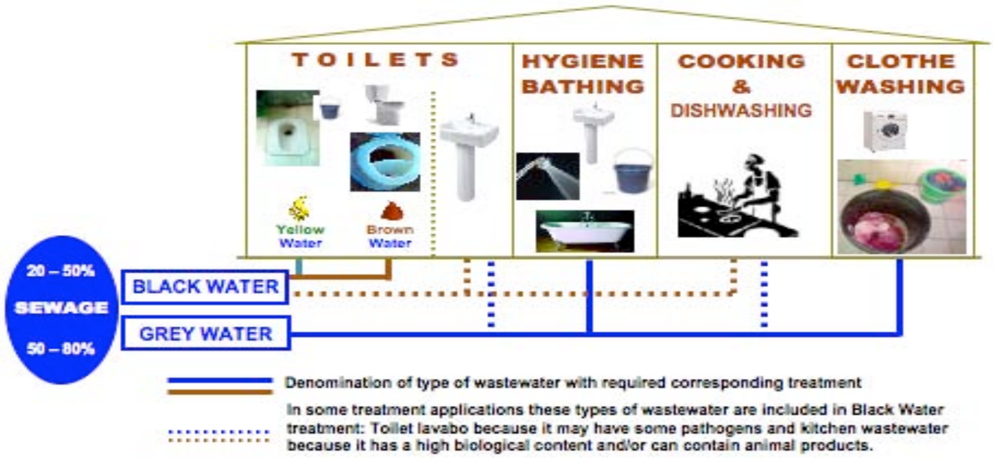


Ranking of Globally Significant Water Quality Issues Affecting the Provision of Freshwater Services for Water Resource End Uses.

Underlined in red: Typical pollution caused by Sewage

Dotted underlined: Excessive Nitrates and Eutrophication are also caused by sewage although important source of these pollutions are also agricultural run-offs. *Courtesy: Millennium Ecosystem Assessment (Content Source); Leszek Bledzki (Topic Editor) "Ecosystems and Human Well-Being: Volume 1: Current State and Trends: Freshwater Ecosystem Services". In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment), http://www.eoearth.org/article/Ecosystems_and_Human_Well-Being:_Volume_1:_Current_State_and_Trends:_Freshwater_Ecosystem_Services.*

2. What is Sewage? Water mixed with excreta, in particular faeces



BASIC FACTS ABOUT EXCRETA - URINE + FAECES = NUTRIENTS

NOTE: presented numbers are indicative averages as there can be important variations from country to country or within a country, depending on type of diet and amount of liquids drunk every day.

Humans excrete on average sufficient amounts of nitrogen, phosphorous and potassium as plant nutrients to grow the 250 kg of crops they need annually (Dangert, 1998).

URINE
3-5 times / day
1.03 Litres / day *(Vegetarian diet)*
1.5 Litres / day *(Protein rich diet)*

FAECES
1-2 times / day
400 Grams / day *(Vegetarian diet)*
140 Grams / day *(Protein rich diet)*

Modified drawing from *Liquid Gold, The Lore and Logic of Using Urine to Grow Plants*, Carol Steinfeld, Green Frigate Books, Sheffield, Vermont *("Urine love", a cartoon from Anorve's book "Psicoanalysis de la Zurrada")*.

QUANTITY PER DAY *(Source: WHO, 1992)*	**URINE**				**FAECES (Wet weight)**				
	Minim	*Max*	*Average*	*Unit*	*Minim*	*Max*	*Average*	*Unit*	Note: Children produce approximately half as much urine as adults.
Protein Rich Diet Temperate Climate:		1.5	1.35 492.75	Liter/Day Kg/Year	130	150	140 **51.1**	Grams/Day Kg/year	
Vegetarian, Tropical climate:			1.03 375.95	Liter/Day Kg/Year			400 146	g/pers/d Kg/Year	
QUANTITY PER YEAR	**WET: > 376 Liters <580 Liters** (93-96% water content)				**WET: >51 Kg <190 Kg** (70-85% water content)				
***Average* PRINCIPAL NUTRIENTS**	**URINE**				**FAECES**				***Average* TOTAL NUTRIENT PRODUCTION**
	Minim	*Max*	*Average*	*Unit*	*Minim*	*Max*	*Average*	*Unit*	
Nitrogen - N	11	15	**13** **4.74**	g/pers/day Kg/Year	1.3	1.5	**1.4** 0.51	g/pers/d Kg/Year	14.4 grams/d **5.25 Kg/year**
Phosphorus - P	0.9	1.09	**1** **0.365**	g/pers/day Kg/Year	0.5	0.55	**52** 0.19	g/pers/d Kg/Year	1.52 grams/d **0.55 Kg/year**
Potassium - K			**2.3** **0.84**	g/pers/day Kg/Year			**0.82** 0.3	g/pers/d Kg/Year	3.12 grams/d **1.13 Kg/year**

Sources:

- World Health Organization, 1992.
- Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ).
- *Composition of urine, faeces, greywater and biowaste for utilisation in the URWARE model*, HŒkan Jšnsson, Andras Baky, Ulf Jeppsson, Daniel Hellstršm and Erik KŠrrman, Dept. of Industrial Electrical Engineering and Automation, Lund University, Sweden.
- (Wolgast, 1993), abstract from *Human excreta for plant production*, Helvi Heinonen-Tanski a,*, Christine van Wijk-Sijbesma b - a/ Department of Environmental Sciences, University of Kuopio, Finland - b/ IRC International Water and Sanitation Centre.
- (Dangert, 1998), abstract from *Source Separation Technique for Recovery of Nutrients from Human Excreta*, Kunwar Durg Vijay Singh Yadav, presentation at the World Toilet Summit, New Delhi, India, 2007.

3. Typical quantities of domestic wastewater per person per day in liters

BLACK WATER

TOILETS : +/- 5 times/day

Average quantities per day (World Health Organization - WHO), 1992


	URINE *Liter/Day*	FAECES *Grams/day*
Protein Rich Diet, Temperate Climate	1.2	140
Vegetarian Diet, Tropical Climate	1.03	400

Type of Toilets — **Average quantities of water per day / per Year**

Squat toilets Bucket = 7 - 20 Liters/day = 2.5 – 7.3 Tons/year

Squat toilets Flush = 60 - 100 Liters/day = 21.9 – 36.5 Tons/year
* Depends on the size of the flush tank

Flush toilets = 30 (6L/flush) - 150 Liters/day = 11 – 54.7 Tons/year
* Since the year 2000 +/- average tanks: ≤ 6 L/flush

1. Dual Flush Toilets 1. = 17 - 20 Liters/day = 6.2 – 7.3 Tons/year

2. Dual Flush Urine Diverting toilets (UDT) 2. = 3.7 – 6.5 Liters/day = 1.35 – 2.37 Tons/year

. = 2 - 3 Liters / flush
. = 0.3 – 1 Liters/flush

. = 6 Liters / flush
. = 2.5 liters / flush

Note: As best ecological practice, water is **not** mixed with excreta (or in minimal quantity as for anal cleansing where it is a cultural practice). Flush toilets are a most wasteful use of water which is often of good and **drinking quality**. An average 6 Liters per flush toilets results in **11 Tons of water** used yearly just for the purpose of transporting **427 to 770 Kilograms** excreta (faeces + urine) or 1 Ton of water to move 39 Kg to 70 Kg excreta. Sewage is furthermore a high disperser of pathogens into the environment, increasing the sizing and costing of required treatment while **faeces and urine are extremely valuable, rich and nutritive substances for soils and plants** (the quantity of nutrients each human generates per year is enough to grow his/her necessary food during one year).

GREY WATER

HYGIENE BATHING

Shower
= 30 - 120 Liters/day for 1 shower of 3 min = 10.9 – 43.8 Tons/year
10-40* average liters per minute, depending on shower head
* Old shower head – **Flow reductor showerhead: 5 – 8 Liters/minute**
- Average shower time: 3 – 7 minutes

Bath
= 50 - 230 Liters/use - Depending on the size of the bathtub = 18.2 – 84 Tons/year

Lavabo
= 20 Liter/day on average = 7.3 Tons/year
Hand and teeth washing: 10 – 40 Liters (Tap running or not – 3.5 – 14.6 Tons/year
(Hands only: 2 – 4 Liters – 8 L running water = 0.7 – 2.9 Tons/year)
(Teeth only: 8 – 12 Liters – 40 Liters with running water – 2.9 – 14.6 Tons/year)
(Shaving: 8-19 Liter - 76 Liters with running water = 2.9 – 27.7 Tons/year)

Bucket shower
= 10 - 20 Liters/Day = 3.6 – 7.3 Tons/year

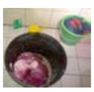
COOKING & DISHWASHING

Dishwashing Hand
= 10 - 20 Liters/day average = 3.6 – 7.3 Tons/year
150 Liters with running water = 54.7 Tons/year

Dishwashing Machine
= 15 - 150 Liters/load = 5.4 – 54.7 Tons/year
Depending on the kind of machine

Food preparation
= 3 - 10 Liters/day = 1 – 3.6 Tons/year

CLOTHE WASHING



Clothe washing by hand
= 10 - 20 Liters/day/Person – 3.6 – 7.3 Tons/year for 1 wash/day
- Depends on how many people's clothes are being washed at once

Clothe Washing machine
= 15 - 50 - 250 Liters/load = 5.4 - 18.2 – 91.2 Tons/year for 1 wash/day
- Industrial machines can go up to 350 Liters / Use
* The European Union has established a norm of 50L which is now becoming international with even lower water consumption machines being produced.

Minimum vital amount of water required: 7.5 Liters/Per person/Per day: taking into account the needs of lactating women *
Water for emergency relief: 15 Liters/Per person/Per day: key indicator in meeting minimum standards for disaster relief (SPHERE, 1998) *
* Source: WHO 2003 "Domestic Water Quantity, Service, Level and Health"

4. Types of Toilets

WASHER or WIPER?

"WIPERS": People who clean themselves with paper or leaves

"WASHERS": People who clean themselves with water

In most Asian and S. East Asian countries as well as in India and in Muslim countries, the majority are washers, whereas in the majority of African (except north-Africa) countries, in Europe, USA, Australia and S. America, people are wipers.

In nature (Open defecation)	Toilets — *With water*: **FLUSH toilets**	Toilets — *No or little water*: **DRY toilets**

40% +/- of the world population (> 7 Billion in 2011) practices open defecation by lack of toilets (UNICEF)

3 to 150 Liters water/person/day

**7-20 L is for bucket squat system*

1 person with an average flush toilet of 6L/flush will spend an average of 11,000 liters of water or 11 Tons/year for the sole purpose of moving 427 to 770 Kilograms of excreta

No water used *

* Except for anal cleansing in some countries

Wiping with leaves, soil, paper, sand, water, ...

Drawing above from "The Schools Water Portal" *http://www.schools.indiawaterportal.org*

Nigeria Health Journal, *News for the sake of your health, http://www.nigerianhealthjournal.com*

Protopooping at Avani, *Oct. 2011. http://panchands.blogspot.com*

Urine + Faeces MIXED

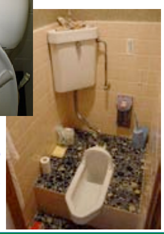
- Full flush toilets
- Pour flush toilets (bucket system)
- Dual-flush toilets

Squat toilet

Sitting bowl "European Style" toilet

URINE FAECES

Dual-Flush Toilet



Japanese toilets

Urine + Faeces NOT MIXED

- Urine Diverting Toilets (UDTs)

Urine Diversion Toilets (UDTs) permit to recuperate the urine and use it for plant growth.

Urine + Faeces MIXED

- Compost toilets

Pre-fabricated compost toilet

Urine + Faeces NOT MIXED

- Urine Diverting Dry Toilets (UDDTs)

Anal cleaning water

Faeces

Urine

Urine Dry Diversion Toilets (UDDTs) permit to use urine for plant growth with minimal maintenance and the faeces for composting and enriching the soil.

STATE OF EXCRETA ACCORDING TO TYPE OF TOILET AND EVENTUAL REUSE

Urine storage, transfer and reuse

Urine storage, transfer and reuse is the same as in UDT (except that the urine should be diluted for reuse).

Below: urine and faeces chambers for apartment complexes, with secondary faeces composting (right)

Right photo: Compost chamber +Irrigation with urine

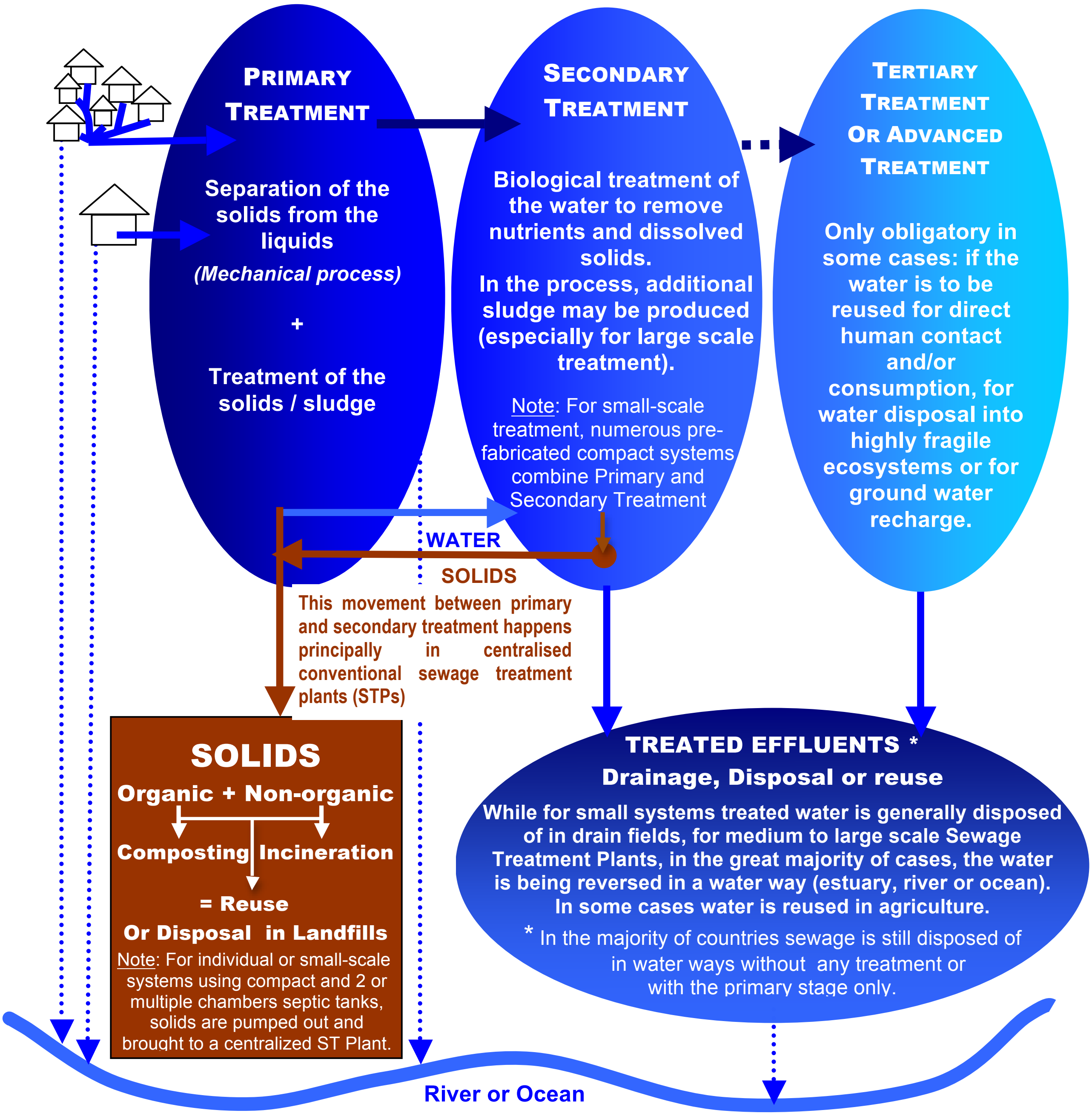
5. Typical wastewater treatment framework

Regulations vary greatly from country to country and even within a country sometimes, but all steps towards proper wastewater treatment have now been universally recognized as consisting minimally of two treatment stages, called "Primary Treatment" and "Secondary Treatment", regardless whether Sewage Treatment Plants (STPs) are centralized or decentralized and what technologies or ecotechnologies are used, sustainable or non-sustainable.

As sewage treatment is considered expensive, many areas still have only primary treatment, if at all. Nonetheless good practice dictates at least a secondary treatment before sewage effluent reuse or disposal into the environment; in sensitive environment, tertiary treatment must be applied as well.

Depending on the techniques used during treatment, each of these steps can take place within a single system or through a succession of systems, use a process heavily reliant on electricity and power supply, with complex technologies and chemical products or use more natural and passive systems such as constructed wetlands, or a combination of both.

Note: *New technologies currently in development enable sewage to be transformed into drinking water by condensation; the energetic and monetary cost are still an impediment however and further economy of scale is necessary, while it could be argued that using the nutrients in sewage effluent, water conservation and/or the use of dry toilets are a much more sensible and economical approach.*



6. Terminology

Terminology

Sewage: is the name given to the mixture of solids with water. Strictly speaking it only includes solids of organic origin (faeces mixed or not with urine as the base material) but is sometimes also used to describe wastewater in general whether it is heavily contaminated with chemicals or with organic or non-organic material.

Sludge: is the more solid part of wastewater (still wet) and will often be viscous and is either of organic, chemical and/or mixed effluent origins.

Effluent or Wastewater: is the liquid part of contaminated water. Depending on the generating activity, the water is contaminated with organic sludge (as with sewage) and/or with chemical sludge.

Black Water: is organic contaminated water mixed with **excreta** (faeces, with or without urine). In decentralized on-site treatment, kitchen water is sometimes included in the black water for treatment.

Grey Water: is wastewater that hasn't been contaminated with faeces; it generally includes wastewater from shower, bath, laundry and sometimes kitchen water. This kind of water doesn't justify as complete a treatment as Black Water does as it doesn't hold nearly as many potential pathogens as is contained in Black Water. It is still often mixed with black water although both kinds of water are increasingly being separated, in particular for medium to large-scale projects (in some countries legislation obliges to do so for projects above 100 +/- residents/guests).

Sewage treatment

Proper treatment of household sewage according to international standards and most countries' legal requirements consists of 2 principal phases in the majority of cases, and 3 stages if you are in a highly sensitive ecological zone. What is required by these standards however concerns only the liquid / effluent part of the sewage. In the majority of cases, it is expected that the solids will be removed and transferred to a specialized facility (usually a governmental owned sewage treatment plant - STP) which will either further treat it, dispose of it, burn it, landfill the ashes or compost it to reuse – some systems will enable on-site treatment and reuse (faecal bags for subsequent composting, vermicomposting).

Treatment can be centralized, decentralized, or a mixture of both as shown previously. Technologies can either integrate a productive use of the wastewater (constructed wetlands, vermicompost, polishing stage in agriculture), be neutral (passively aerated and evaporation ponds, multi-chambers septic tanks) or be highly energy and technological complexity-dependent (compact systems requiring electricity and/or chlorine for small-scale applications, activated sludge, aerated lagoons, membrane bioreactors, chlorinators, Ultra violet treatment, etc. for large scale applications).

PRINCIPAL TREATMENT PHASES

1. PRIMARY TREATMENT

Consists of separating the solids from the liquids. This takes place principally through techniques that allow a phase of sedimentation, where the solids deposit at the bottom of a tank. Depending on the amount of sewage this phase can include a screen to separate larger solids from smaller solids. For small-scale treatment, a septic tank is generally used, or faecal bags, sedimentation tanks or any other similar technology. Depending on the system used, bacteria will generally start the decomposition and digestion phase of the solids.

2. SECONDARY TREATMENT

Consists of the treatment of the water according to several parameters such as the Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Faecal Coliform bacteria, Total Suspended Solids (TSS), while metals and other contaminating chemical components will also be looked at for non-organic water. In some situations, Nitrogen and Phosphorus will also be considered, in particular or large concentrations of human activity or if the treated water is disposed of in highly sensitive ecological areas prone to eutrophication (excessive nutrients which will cause accelerated growth of some plants and causing oxygen depletion and eventual death for the remaining plants and aquatic life).

3: TERCIARY TREATMENT

If you are in a highly sensitive ecological zone or if the water is to be reused for human consumption or certain food production, water contamination will need to be furthered removed so that the wastewater will undergo tertiary treatment with higher purification rates expected than for secondary treatment.

DISPOSAL OF TREATED WATER

Depending on the volume and nature of the water, either the treated water is being disposed of in the soil through drainage trenches, reused (agriculture, landscaping, reintroduced in the piping), or being discarded in a nearby receptor body (river, ocean, lakes), the most common practice. Depending on the ecosystem recipient of discharge, secondary treatment may need to exceed « normal » standards.

7. Example of treatment systems

<u>Example of Primary Treatment:</u>

SEPARATION BETWEEN SOLIDS AND WATER





<u>Example of technologies options (conventional + non-conventional):</u>

From the left to the right: screening, activated slude with settling tank, faecal bags, septic tank (2 chambers minimum, in concrete or pre-fabricated), constructed wetlands (also including secondary treatment).

<u>Example of Secondary Treatment:</u>

TREATMENT OF SEWAGE EFFLUENT






<u>Example of technologies options (conventional + non-conventional):</u>

From the left to the right: Activated/Aerated sludge, Peat treatment, Constructed Wetland, Compact treatment / Septic Tank (3 chambers minimum, in concrete or pre-fabricated, or with electricity for aeration and chlorine), Treatment with Vetiver zizanoides.

<u>Example of Tertiary Treatment:</u>

EXTENSIVE TREATMENT OF SEWAGE EFFLUENT FOR SENSITIVE ZONES




<u>Example of technologies options (conventional + non-conventional):</u>

From the left to the right: Constructed Wetland, membrane systems with circular aeration/oxygenation, UV, lagoons.

<u>Drinking quality water:</u>



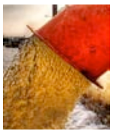
<u>Example of technologies options</u>

From the left to the right: Time and natural processes, Membrane / Reverse Osmosis processes, UV, oxygenation and/or chlorine dependent systems.

8. How is wastewater purified?

Regardless of the technologies used, so called "conventional" versus "non-conventional", to achieve sewage treatment, each process relies on the same fundamental elements shown in the diagram below[1]: Microorganisms and Oxygen. The principal difference resides in how the oxygen is produced (naturally through the roots of plants or through aerating blowers relying on electricity).

Water has always been a natural vehicle for transporting and processing organic waste. The **water cycle** purifies water by moving it through soil, plants and the atmosphere where natural and complex processes remove and utilize pollutants as nutrients. For thousands of years humans have either avoided mixing water with their excreta and reused it productively or used water to dilute the waste they produce and carry it away from the places where they live. These places where sewage was/is sent were often natural wetlands when available or waterways with a rapid flow. This "waste" is then purified by natural processes, away from human contact. This process however takes time and populated areas have been creating more wastewater than natural cycles are capable of processing on their own and in the last 50 years; wastewater discharged to these water bodies have also carried heavier loads of synthetic chemicals and other toxic elements not found in domestic sewage.

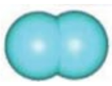


Sewage

+

Microorganisms

+



Oxygen

2 ways to bring oxygen to the water to allow biological brakedown by microbes:

The use of plants in sewage effluent treatment

Water and nutrients are processed by the sun and in some cases are filtered through or held in a media such as soil, sand and/or gravel. These conditions are highly favorable to various bacteria and micro-organisms playing an active role in the digestion of all organic matter. At the same time, plant roots act as pumps bringing down oxygen to the organisms (creating a relationship of symbiosis). Plant leaves act as evaporators of water and oxygen so that excess water evaporates off of the leaves into the atmosphere (a process called evapotranspiration).

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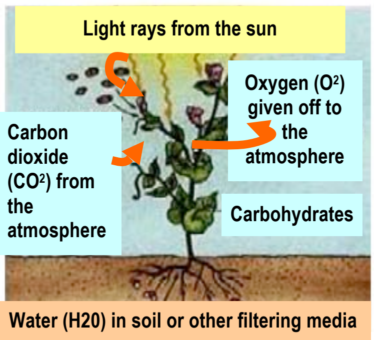
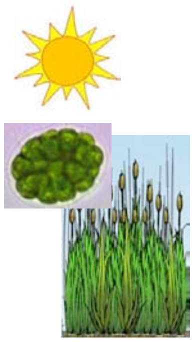


Evapotranspiration principal processes



NON-CONVENTIONAL TECHNOLOGIES

NATURAL SYSTEMS

> Land space

< Energy

■ No chemicals

Eg: Constructed Wetlands, Ponds, Sand Filters, Carbon filters, Rock filters, ...

SUSTAINABLE

CONVENTIONAL TECHNOLOGIES

ENERGY INTENSIVE SYSTEMS

< Land space

> Energy

■ Chemicals

Eg: Rotating Biological Contactors (RBC), Activated sludge treatment, Aerated lagoons, Membrane bioreactors, Chlorination, Sodium hypochlorite, ...

NON-SUSTAINABLE

[1] Drawing inspired but modified from *Los sistemas naturales para la depuración de las aguas residuales urbanas: experiencias en Andalucía*, Juan José Salas Rodríguez, Centro de la Nuevas Tecnologías del Agua (CENTA), Agencia Andaluza del Agua (CMA), Ministerio de Medio Ambiente Planta Experimental de Carrión de los Cespedes (PECC), July 2007.

9. Example of Natural and Energy-Intensive sewage treatment plants (STP)

Non- "Conventional » STP

- Treat wastewater as a resource.
- Separates types of wastewater when possible.
- Decentralised treatment when possible or semi-centralised.
- Relies on natural processes for treatment.
- No use of chemical products + no additional pollution emission in the treatment process.
- Treatment is taylored according to nature of wastewater and purification rates desired.
- Creator of added value

"Conventional" STP

- Treat wastewater as waste to be disregarded.
- Tends to mix all kinds of wastewater into one centralised treatment plant.
- Centralised treatment.
- Relies on electricity and complex technologies.
- Relies often on synthetic products and chemicals (emission of additional pollution in the treatment process).
- Discharge in waterways (with a quality often below safety levels for release into the environment).
- No creation of added value

Constructed wetlands

Treatement with Vetiver

Duckweed system

Faecal matter: Vermicomposting

Green Filter: Fast growing timber plantation

Urine stored for 6 month + Application in agriculture

Rotating Biological Contractor

Anaerobic Digestor

Chlorination unit

Membrane + UV system

Denitrification

Aeration

Sludge incinerator

Common technologies

Screener to separate solids from liquids

Lagoons

While you are rarely required to be responsible to treating the sludge generated in the treatment system, below is a rapid overview of options for productive reuse of sewage solids:

Production of organic fertilizer

Humans excreta holds high levels of nutrients, on average sufficient amounts of nitrogen, phosphorous and potassium as plant nutrients to grow the 250 kg of crops we need annually (Dangert, 1998). **Urine** alone, collected from one person in a year, is sufficient to fertilize 300–400 m^2 of crop. Urine being almost sterile doesn't require intensive treatment but storing time, which varies according to origin and amount of urine (a family garden can be fertilized immediately with urine, for a garden of several families, recommended storage time is 1 month – for large communities, 1 year). Applied ratio for fertilizing are between 1 part Urine to 3 parts Water or 1 part Urine to 5 parts Water for agriculture and is applied in furrows in the soil at the feet of the plants (it is the soil that needs to be nutritive, not the plant whose roots get nutrients from the soil); the mixture should never be applied on leaves directly as it will burn them. The area where the fertilizer is applied should then be covered by soil to avoid nitrogen loss through evaporation. **Faeces** and sludge however must go through a thorough compost stage to ensure pathogen removal where they will transform into highly nutritious humus after 3 to 12 month minimum, depending on the composting method used and heat levels reached. At a larger scale, a vermicomposting farm (composting with the assistance of earthworms) permits the production of vermicompost, highly valued in agriculture; it can also be packaged and sold, becoming a wealth-creating tool. Recommended worms are *Eisenia foetida* (Red worm, tiger worm), *Eudrillus euginae* (Night crawler Local worms), *Perionyx excavates* and *Perionyx sansbaricus* (e-Arik Publication No.: 13). A recent governmental study in Florida (Orange County's Environmental Protection Division – OCEPD) has shown that Vermicomposting meets the highest standard of safety for reuse or disposal in the environment (Class A biosolids) (Bruce R. Eastman, "Spiking the Biosolids, Achieving pathogens stabilization using vermicomposting", BioCycle Magazine, Nov. 1999,) for example while India has been using manure vermicomposting successfully for decades.

Production of biogas / Energy

Depending on the country and project location, small, medium and large units of biogas production are available for the treatment of sludge. One type of UASB system for example (Upflow Anaerobic Sludge Blanket Reactor) enables the production of 10 Liters per full time resident per day for an equivalent production of sewage of 150 Liters per person per day. These 10 Liters will have an energy content of about 0.0625 Kwh. Electricity conversion efficiency is about 33 % which will therefore represent 0.020625 kWh electricity per day / PE. *(WWG study for Fuavahmula Island, the Maldives, 2009).*
Example: 8000 people would produce about 120m^3/day of biogas from their black water which would permit to produce enough electricity for 1000 homes using about 250 Wh light at night (a few energy saver bulbs for a few hours). In this case, the cost for a 25 kW CHP plus gas equipment would be around 120,000.00 US$, shipment cost to location of use and installation not included, 2009 prices.

Other systems enable 1 Kg of human faeces to produce an average 50 Liters biogas, 1 Kg of cow manure to produce 40 liters and 1 Kg of chicken manure to produce 70 Liters biogas. (Source: *Des solutions adaptées pour l'assainisement. Exemple de technologies innovantes à faible coût pour la collecte, le transport, le traitement et la réutilisation des produits de l'assainissement,* Netherland Water Partnership (NWC), PRACTICA, International Water and Sanitation Centre (IRC), SIMAVI, Partner to Enterprising People (ICCO), Partners for Water, World Forum on Water, Mexico, March 2006).

Non-organic or mixed organic/chemical solids

Options for the non-organic (e.g. industrial waste) sludge treatment and recycling depend largely on the nature of the sludge and is a field currently undergoing lots of research. If the wastewater is largely oil/metals/chemical-based, constructed wetlands with specific plants or Vetiver-based remediation systems are highly recommended, as the plants will integrate much of the "toxins" in their plant tissue which may then be used as source of biofuels for example. If you have numerous plastics in the sludge, a recycling or conversion plant may be considered. Technologies are numerous in this nascent field and a case-by-case study is necessary.

11. Sewage treatment placement on a property

We are indicating these measurements taken from different resources just as indicative information; they are in no way authoritative as legislation varies from country to country and sometimes within provinces. The nature of your site (kind of soil, presence of high or low water table for example) will also greatly determine good practice, so that you must check with local legal requirements.