SUSTAINABLE STAINLESS

Stainless Steel in Sewage Treatment Plants

A Clean Solution for Pure Water

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Stainless steel sewer pipe system
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introduction

Water – the blue gold of the blue planet, used in so many ways: for agriculture, for the processing and preparation of food and beverages, for heating and cooling, for energy generation, and for the production of a wide spectrum of industrial and consumer goods. About 70% of the world's surface is covered with water, but less than 3% of it is fresh water, making it a very precious commodity. The use of water produces wastewater. Like any other waste products, wastewater is a valuable, sustainable resource and should be treated appropriately.

The aim of treating wastewater is not just to recover water for reuse. It also helps to protect people and the environment from contaminants in the water. Furthermore, wastewater contains valuable recyclable materials which can be used to generate heat (from biogas), make fertiliser (from sewage sludge), and create service water for domestic and industrial use.

The equipment and machinery in wastewater treatment plants are exposed to aggressive and corrosive substances, the central reason why these plants utilise stainless steel[1]. The corrosion resistance of stainless steel combined with its durability and minimal maintenance requirements ensures long and economic life cycles. And when the component reaches the end of its service life, stainless steel is 100% recyclable. Is there a better material for creating a sustainable technical solution?

Stainless steel slide gates between two wastewater basins
(Photo: Nickel Institute, Toronto, Canada)

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WHAT MAKES STAINLESS STEEL A SUSTAINABLE MATERIAL?

Before we can determine whether stainless steel is a sustainable material, we should first define what we mean by sustainability in relation to what is known as the triple bottom-line: People, Planet and Profit.

1. People

The material, in its use or in its production process, respects the human being, especially in terms of health and safety. A sustainable material does not harm the people working to produce it, or the people who handle it during its use, recycling and ultimate disposal.

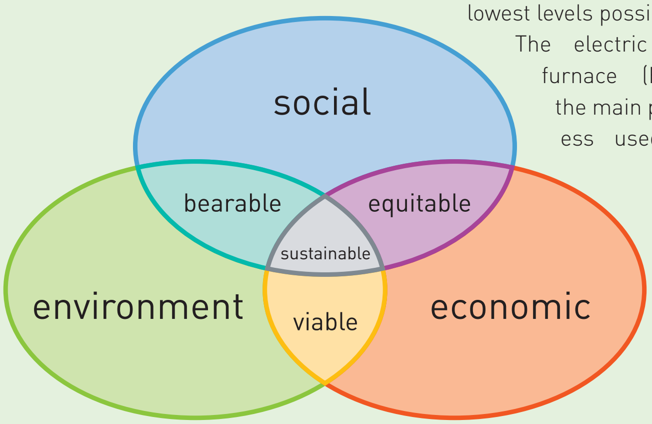
Stainless steel is not harmful to people during either its production or use. A protective layer forms naturally on all stainless steels because of the inclusion of chromium. The passive layer protects the steel from corrosion – ensuring a long life. As long as the correct grade of stainless is selected for an application, the steel remains inert and harmless to the people who handle it and the environment. These characteristics have made stainless steel the primary material in medical, food processing, household and catering applications.

2. Planet

The emission footprints of the material, especially those related to carbon, water and air, are minimised. Reuse and recyclability are at high levels. The material has low maintenance costs and a long life, both key indicators that the impact of the material on the planet is at the lowest levels possible.

The electric arc furnace (EAF), the main process used to make stainless steels, is extremely efficient. An EAF has a low impact on the environment in terms of both CO_2 and other emissions. The EAF is also extremely efficient at processing scrap stainless, ensuring that new stainless steel has an average recycled content of more than 60%.

Stainless steels are easily recycled to produce more stainless steels and this process can be carried on indefinitely. It is estimated that about 80% of stainless steels are recycled at the end of their life. As stainless steel has a high intrinsic value, it is collected and recycled without any economic incentives from the public purse.



Source: Wikipedia

3. Profit

The industries producing the material show long-term sustainability and growth, provide excellent reliability and quality for their customers, and ensure a solid and reliable supply-chain to the end consumer.

Choosing stainless steel for an application ensures that it will have low maintenance costs, a long life and be easy to recycle at the end of that life. This makes stainless an economical choice in consumer durables (such as refrigerators and washing machines) and in capital goods applications (such as transportation, chemical and process applications).

Stainless steels also have better mechanical properties than most metals. Its fire and corrosion resistance make stainless a good choice in transportation, building or public works such as railways, subways, tunnels and bridges. These properties, together with stainless steels' mechanical behaviour, are of prime importance in these applications to ensure human beings are protected and maintenance costs are kept low. Stainless also has an aesthetically pleasing appearance, making it the material of choice in demanding architectural and design projects.

Taking into account its recyclability, reuse, long life, low maintenance and product safety, the emissions from the production and use of stainless steels are minimal when compared to any other alternative material. A detailed and precise analysis of the sustainability of stainless steel makes the choice of stainless a logical one. This might explain why, as society and governments are becoming more conscious of environmental and economic factors, the growth in the use of stainless steel has been the highest of any material in the world.

SEWAGE TREATMENT - PROCESS OVERVIEW

Wastewater is a broad term that includes sewage (including municipal water-borne waste and surface run-off) and water polluted by industrial production. The latter is outside the scope of this brochure which focuses on municipal wastewater treatment.

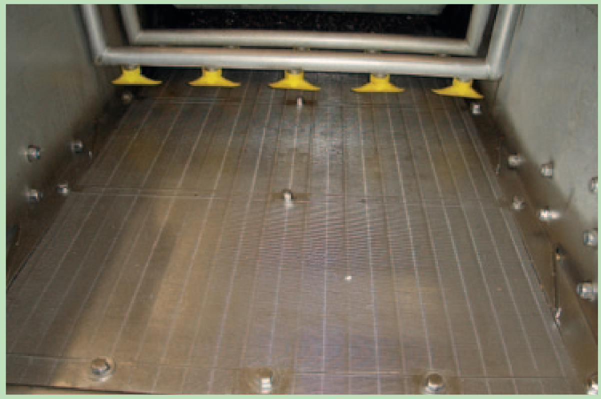
Sewage is usually treated in large-scale, centralised wastewater treatment plants (WWTPs). In areas where there is no connection to a central sewerage system, the solution is a customised, decentralised WWTP.

Stainless steel overflow gutter
(Photo: Informationstelle Edelstahl Rostfrei, Düsseldorf, Germany)

Numerous techniques including physical, chemical and biological processes are applied to sewage. This results in a waste stream and sludge. The process begins with pre-treatment. During this stage easily recoverable solids are removed from the wastewater flow. Larger objects are retained as the water passes through screens while mineral matter (for example, gravel or sand) settles to the bottom as the water passes through channels or traps. Pre-treatment helps to avoid operational problems in the subsequent treatment process. Generally there are three stages in the treatment process:

1. Primary treatment. After pre-treatment, the wastewater is placed in sedimentation tanks (known as primary clarifiers). While the raw wastewater is held in these quiescent basins, heavy solids sink to the bottom where a scraper drives the primary sludge towards a hopper from where it is pumped away for separate treatment. Floating materials (for example, grease or oil) are skimmed off the water surface. Depending on the end use of the wastewater, it can be discharged, or undergo secondary treatment.

2. During secondary treatment, the biological content in the water is degraded by means of various biological processes followed by secondary settling. With enough oxygen and a substrate on which to live, bacteria and protozoa consume biodegradable soluble organic contaminants in the water and bind the less soluble contaminants into floc (flakes). In secondary clarifiers the resulting biomass (biological floc or filter material) is separated from the sewage water, producing water with very low levels of organic material and suspended matter. The biomass (secondary sludge) is conveyed to sludge treatment before it is disposed of.



Screens
(Photo: I.D. Inox, France)

3. The last stage, known as tertiary treatment, ensures that the effluent meets required standards before it is released into

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the environment. This stage may include processes such as filtration (through sand or other media), adsorption to activated carbon, settlement and biological improvement through storage (known as lagooning), ion exchange and the removal of nitrogen and phosphorous.

Disinfection (using chlorine, ozone, or ultraviolet light) of the water is performed to reduce the number of disease-causing micro-organisms. Disinfection can take place after secondary clarification or tertiary treatment.

Wastewater treatment does not end with clean water. The residuals obtained in the different stages (such as screenings, grit or sludge) undergo special treatment which enables them to be discharged safely, utilised in new applications (for example, as fertiliser) or reused (for example, grit). The biological processes used during secondary treatment lead to the production of biogas which can be utilised to generate electrical power[2-4].

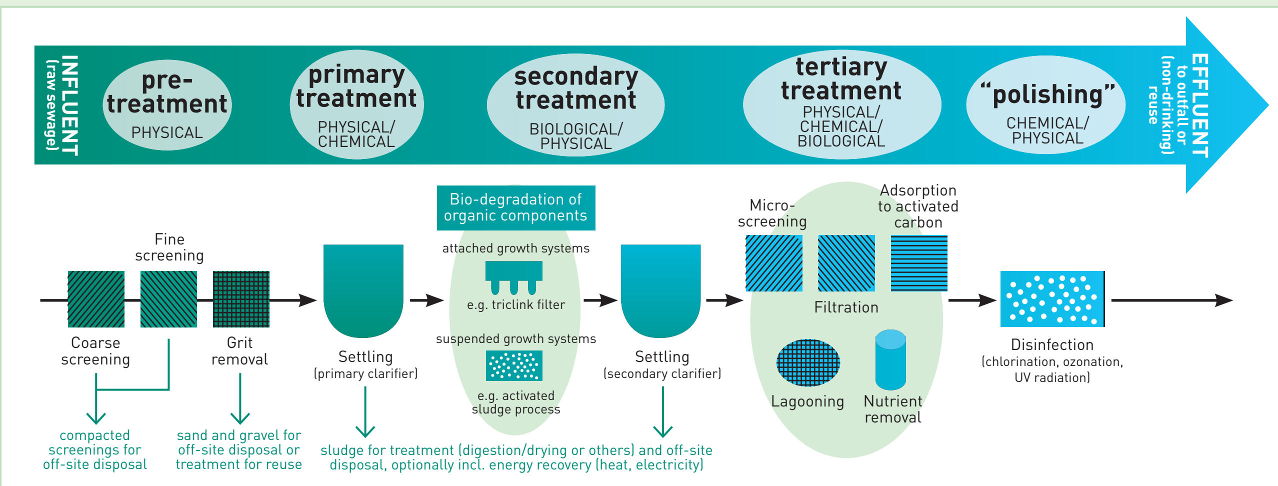
STAINLESS STEEL IN WASTEWATER TREATMENT SYSTEMS

A WWTP is a complex, sophisticated system with a high-level of standards for the entire plant including technical installations. The materials needed to construct a WWTP must be able to withstand the wide range of corrosive conditions that are encountered during operation. Two types of corrosion in particular form the main threat to the safe operation of a WWTP. They are:

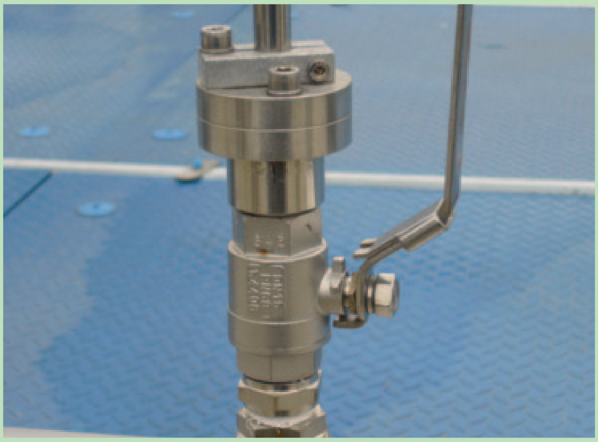
- Micro-biologically influenced corrosion (MIC)
- Abrasive corrosion.

MIC is caused by micro-biological agents under certain environmental conditions. The biological agents modify the local chemistry by producing acid which promotes various forms of corrosion. Extremely high corrosion rates are common which can lead to total failure of a system within a few years. Depending on the material used in the system, extensive cleaning and chemical treatment with biocides may be required.

Abrasive corrosion is the gradual degrading of a surface through mechanical wear. In wastewater mechanical wear can be caused by entrained air bubbles or suspended matter.



Municipal wastewater treatment process



Valves at the La Rochelle plant in France
(Photo: I.D. Inox, France)

Materials that are less hard than stainless steel or materials with rough surfaces are more susceptible to this type of corrosion. The design of a system also plays an important role. Designs that create turbulence, flow restriction or obstruction of the wastewater flow should be avoided.

If a clean, environmentally safe and cost-effective plant is aimed for, there is no better material than stainless steel. A multitude of stainless steel products therefore finds its way into WWTPs. Some examples include:

- Manhole covers
- Pipes and fittings
- Pumps
- Screens
- Tanks and tank linings
- Valves
- Wall ducts
- Components used in settling tanks, grease and oil separation, dewatering and compacting, grit and sludge treatment, and filtration
- Auxiliary and architectural equipment (for example, doors, gates, covers, stairs, ladders, platforms, railings, and roofing).

These applications require stainless steel in a variety of semi-finished products, including flat material, tubes and bars. The most commonly utilised stainless steels in WWTPs are chromium-nickel, chromium-nickel-molybdenum and duplex (ferritic-austenitic) steels. The exact type of stainless steel used depends on the amount of corrosion resistance and strength needed for the particular application.

For above-water applications, stainless steel grade Type 304L/1.4307 is customary and meets both corrosion resistance and cost considerations. When it comes to systems to move the waste water (such as piping) and underwater applications, the molybdenum-containing grade Type 316L/1.4404 is preferred. The duplex steel grade UNS S 32205 (also referred to as EN 1.4462) is utilised if both mechanical properties and corrosion resistance are important. Duplex grades are often used to make large parts which move and therefore need to be of light weight.

Many of the parts and components in a WWTP could be produced with other materials which may have a lower initial cost. However, the long-term cost of maintaining the equipment should be factored into calculations before material selection is finalised. The following points should be taken into account[5]:

An entirely transportable stainless steel prefabricated depurator of San Martino di Castrozza, Italy
(Photo: Centro Inox, Italy)

- Zinc coatings of galvanized carbon steel are not really repairable when damaged. This results in rapid corrosion and the need to replace defective parts. Preparatory work prior to final assembly is also quite extensive.
- Heavy-walled pipes of ductile cast iron cannot be welded which means that many fittings are needed for on-site assembly. Re-coating for corrosion protection becomes necessary after a few years of service. The latter also applies to resin-coated carbon steel parts.
- Aluminium parts are rather difficult to install on-site. They do not resist ammonium and ammoniac and are therefore prone to pitting.
- Concrete is prone to cracking or even separation, especially when a low-quality concrete mix is applied. A concrete surface is rougher than a metallic surface and thus more susceptible to contamination and corrosion.

Stainless steel will improve efficiency and reduce maintenance, and is overall the most cost-effective choice. Stainless is available in many shapes and grades and is easy to handle during both assembly and installation due to its formability and weldability. In service, stainless steel proves to be a reliable, long-lasting material. Its high strength and durability also permit high flow rates. Excellent corrosion resistance reduces costs associated with cleaning, maintenance and repair.

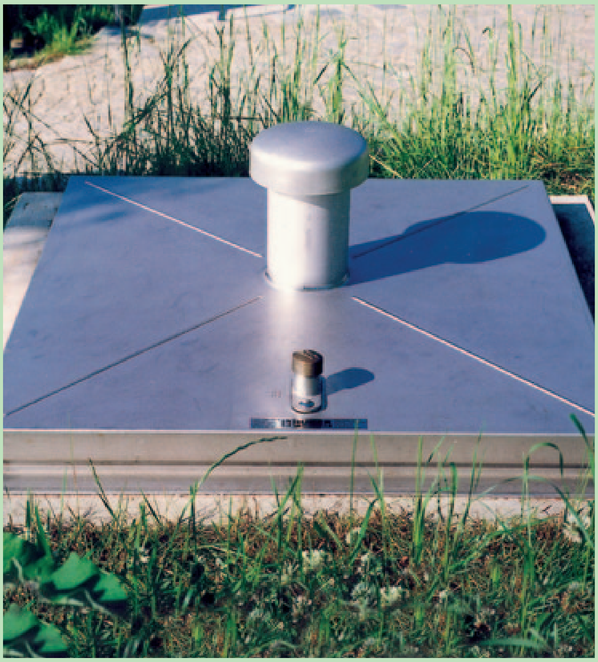
It is important to select the appropriate stainless steel grade for each application and to prevent contamination by contact with objects that may corrode themselves. Metal leaching is eliminated and stainless does not contaminate the water. At the end of its life, stainless steel is 100% recyclable, making it friendly to the environment and a valuable resource for future applications.

THEORY BECOMES PRACTICE – STAINLESS STEEL SUCCESS STORIES IN WASTEWATER TREATMENT

Operators of WWTPs and the manufacturers of the equipment used in them appreciate stainless steel for a number of reasons. They are very much aware of its technical and economical advantages.

Georg Huber, CEO of HUBER SE testifies

"We offer our customers innovative and competitive high-quality products, together with systems and services that help save, protect and clarify water and also process and utilise the resulting residual materials. We see water, wastewater and energy as resources. We achieve sustainable and profitable growth through leading technology and economic solutions.



Stainless steel ventilated manhole cover
(Photo: HUBER SE, Berching, Germany)

Stainless steel rotary drum fine screens with integrated screenings washing installed in parallel
(Photo: HUBER SE, Berching, Germany)

An example of a sewage plant, Paju, Korea.
(Photo: POSCO E & C, Korea)

For HUBER, stainless steel products are the best solution for water and wastewater treatment applications – municipal and industrial. The higher price of stainless steel is more than compensated by lower labour costs for manufacturing and maintenance and by its superior durability and corrosion protection of the products. A common saying is: "Cheap today is expensive tomorrow." The reverse is equally true."[5]

Stainless Steel in Korean WWTP

Constructing wastewater treatment facilities in Korea is an important issue and much new investment is expected in this area. POSCO E&C, located in Pohang, Korea, is one of the leading companies in the water treatment sector in Korea.

Jong-Woo Lee manages the Environmental Business Group at POSCO E&C and has great confidence in using stainless steel in the products his company creates. "In many cases of our projects, the use of stainless steel is common, especially for those parts that come into contact with wastewater," says Mr Lee. "The material should be corrosion resistant in this wet atmosphere. Our preference for stainless comes from its excellent durability, largely due to its high corrosion resistance, and its aesthetic properties. Sometimes we use fibre reinforced plastics (FRP), but they break easily due to their lower strength.

There are several applications for stainless in our products. For example, the air supply tube which provides oxygen to the micro-organisms that breakdown the impurities in the wastewater. The tube is a core part of the system, and provides the oxygen the micro-organisms need to multiply. Stainless is also used to make the transfer pipes for re-purified water. We normally utilise Type 304/1.4301 for these applications, but sometimes Type 316 /1.4401 is also used. Due to its benefits, especially in a wet atmosphere, we put stainless on the building specifications without any hesitation."[6]

Cleaning up with stainless

Application of stainless steel is diverse and becoming more so. Where in the past cost-balancing might have encouraged the use of an alternative material, today's considerations factor in longevity and sustainability - two areas where stainless steel excels. Joe Gill is managing director of Smith & Loveless, a company delivering energy-efficient water and wastewater treatment and pumping systems. He says his company prides itself on delivering high performance product with lifecycle cost savings and that the use of stainless steel is an important part of this.

Clarifiers built to last

"Many elements of our systems are designed in stainless," says Mr. Gill. "A good example would be the secondary-stage clarifiers at wastewater treatment stations. These pick up the job of recycling wastewater by separating out the solids and grit from sludge - the process requires a tough rotator scrapper mechanism and this is where our stainless steel clarifiers come into play." The company makes 10-12 clarifiers a year, with several exported to Australia and further afield. In many cases, it is cheaper for overseas companies in Australia or the Pacific Islands to source this plant from New Zealand, particularly when factoring in cheaper labour rates and the exchange rate as it currently stands. A recent project for Smith & Loveless saw the introduction of a substantial stainless steel clarifier for a Te Manga factory, with other pieces in the pipeline for treatment plants on the North Shore and Rotorua.

(Photo: Smith & Loveless, New Zealand)

(Photo: Smith & Loveless, New Zealand)

Same but different

"While the nature of these wastewater systems is universal, we create customised clarifier solutions for each project by adjusting existing templates," says Mr. Gill. "Generally, the stainless used is 316, while 304 would handle most aspects of the machinery's job, the potential for gas corrosion is there and 316 can take this level of punishment." Mr. Gill says that stainless is growing in other aspects of water treatment as well.

In the pipeline

"Increasingly, stainless steel is being used for transfer pipework, particularly on pipes of up to 150 mm in diameter," he says. "Where plastic has proved economical in the past, its predicted long-term use hasn't really factored in the detrimental impact of sunshine on the pipes, which breaks them down over time, resulting in hefty replacement costs." Another advantage is limiting mechanical damage when pipes need repairing – stainless steel can take the odd knock or scrape pretty much unscathed. The same bump to a plastic pipe might compromise its integrity.

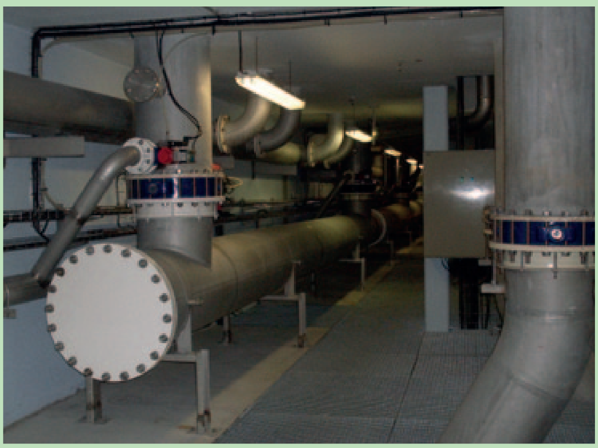
A growing presence

"Ten years ago the widespread use of stainless steel was unheard of in this industry," says Mr. Gill. "Now it is fast becoming a commonplace. Another reason for this, besides stainless steel's durability, is the fast-growing trend towards sustainability. "Stainless steel is 100% recyclable - providing benefits to the planet, and also to quantity surveyors, designers and specifiers when looking to create a 'green star' water treatment project." Smith & Loveless works with stainless steel in many guises, including pumping systems, wastewater, and water treatment plants.[7]

Waste Water Treatment Case Study: Annemasse – Les Voirons

The Annemasse – Les Voirons waste water treatment plant is located in Haute-Savoie, France. The facility, constructed in 1999, is shared by the local communities and is designed for a population of 80,000.

A lot of stainless steel (mostly grade 304L /1.4307) has been used in the plant. Pipes, agitators, screens, fasteners, valve parts, chains, cable racks are just some of the applications where it is utilised. The equipment is in service 24 hours a day, seven days a week.



Water and air inflow, water outflow and drain pipes of the biological treatment unit (Photo: the City of Annemasse, France)

"The overall performance of stainless steel is quite good," explains Isabelle Calligé, Plant Manager at Annemasse – Les Voirons. "Nearly all of the original equipment is still successfully in operation. The only significant problem was caused by a few welding defects." [8]

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