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Dredging: What is it and how can we Fix and Re-use Contaminated Dredged Material?

Dredging is an ancient practice that goes back to the creation of the first ports in early cities. Back then much of the materials were used to fill in other parts of cities, such as low areas and wetlands that once surrounded the first open port cities. This was done to allow safe harbor for ships and to allow larger vessels to travel up rivers. Early dredging was mostly done by hand. Romans were known as great engineers and to prove it they invented the first mechanical means of dredging “Romans accomplished navigational dredging with something similar to “spoon and bag” dredges, where a boom with a scoop on its end was pushed through or swept across soft sediments until an attached bag was filled, then levered up and dumped in a waiting barge for disposal elsewhere.” (Mountford, 2000.) As shipping became more important to renaissance Europe so did the need to dredge larger and deeper shipping channels to accommodate larger ships. Dredging technology began to evolve with large ocean going ships “...by the early 1600s, employed so-called “mud mills”: rotary tread wheels, powered first by men, then by horses, that ran a continuous chain of buckets traveling on an extendible boom that chewed away and excavated the bottom when pressed against it.” (Mountford, 2000.) As the world began to industrialize dredging became more and more

crucial to the shipping economy which brought these new mass produced goods to market. As technologies became better at collecting dredge material the question began to surface what do we do with all this excess material? At first it was as easy as moving it out to sea or as fill for quickly expanding cities. Soon our industry, which was located at the shore mostly, contaminated much of the material we were removing making it unsuitable for other uses or off-shore dumping. Over the past 50 years our need to dredge navigable channels has lead to a huge increase in the amount of material that was needed for storage. Today two main methods are used to hold and/or treat contaminated dredge material.

Confined Disposal Facilities

The most widely used method of holding this contaminated material in the past century is the Confined Disposal Facility (or CDF.) The CDF is essentially a large dike meant to contain the material. “CDFs function as settling basins, in-terms of water treatment technology. Typical CDF’s are designed to retain 99.9% of sediment particles disposed” (Koerner, 2003.) This is meant to keep the contaminants in the sediment from leeching into the surrounding area and bodies of water. These methods of disposal are not a permanent solution for the disposal of these materials, and only stores not decontaminates it.

This is beginning to change with more stringent water quality regulations and increased remediation efforts, for example new Geosynthetic technologies allow water out of the CDF’s into bodies of water without allowing contaminants to leach out as well. The first

use of this technology was in a section of The Grand Calumet River in Gary, Indiana,

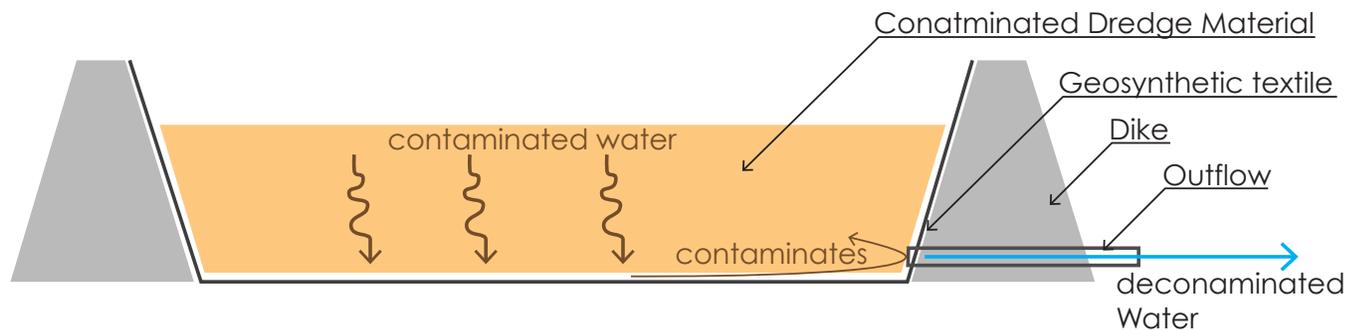


Diagram of how GeoSynthetics work in a CDF

was highly contaminated with a variety of undesirable chemicals from steel production. As part of this project they created an upland dewatering CDF. “Design and construction of a wastewater treatment plant for the treatment of dredge water generated during sediment removal and return of the treated water to the Grand Calumet River through a permitted outfall.” (Koerner, 2003) The creation of these new CDF’s more effective with the use of geosynthetic materials compared to traditional blocking materials such as vinyl. These geosynthetic materials allow greater safety for the surrounding environment and help protect the water quality of already degraded areas. Though these solutions are cheaper than traditional CDFs it is still very expensive to dredge material, transport it, and create the infrastructure necessary for these huge undertakings.

Re-Imaging CDFs

As ideologies and technologies have been changing we now realize that CDFs are not the best option for treating dredge materials. As time goes on and these sites become filled and unusable what is to become of the land that is now left behind? We are left with vast swaths of land which are made of silt and sediment which is not safe to build

on or is too contaminated for human uses. Many of these closed sites have been left for nature to take over, which allows for the natural de-contamination of the sites. Some see this as an opportunity to create habitat for wildlife in and near cities. “Various CDF’s are transformed into parkland, wildlife habitats, and or function as shoreline protection structures. An example is a small CDF at Kenosha, Wisconsin that is now partly city parkland, with an adjacent marina, that has been built utilizing the CDF structure.” (Long Term Management of Confined Disposal Facilities for Dredged Material, 2009) By re-imagining what was once a storage site into a public or environmental use will allow us to move past the undesirable history of the site as well create a productive landscape that can be enjoyed not shunned.

Phytoremediation

“Phytoremediation is the use of plants to remove contaminants from the environment. By harnessing the natural capabilities of plants we can remediate toxic soils, groundwater, surface water, and sediments... Instead of removing tons of toxic soil and filling the site with new clean soil, plants remove contaminants from the soil and store it within their plant tissue. In some cases, the plants themselves then have to be removed as hazardous waste, other plants break down the toxins and eliminate them altogether.” (Kühl, 2010) This process is something that happens naturally to a site if nature and time are allowed to take over. Now we are beginning to realize we can use these natural processes to remediate degraded site. One of the most promising uses is decontamination of dredged materials, which is typically contaminated. For example “In Flanders, Belgium, only about 6-7% of the underwater soils is considered as non

contaminated. Nowadays, sediments dredged from inland waterways are mostly being land disposed in confined facilities. In the past, sediments have been disposed along the shores of the waterways without precautions for contaminants eventually present. As a result, many areas containing elevated metal contents because of historical sediment disposal have been identified along waterways in Flanders.” (Vervaeke, 2005) Luckily many fast growing plants, such as Willow (*Salix spp.*) and Poplars (*Populus spp.*), are excellent for removing heavy metals and other contaminated materials. Especially, in moderately contaminated soils that are present in much of the material being extracted out of harbors and navigation channels. Plants have four methods of decontaminating degraded soils.

1. **Phyto-Extraction:** plants take up contaminates mostly metals, metalloids, and radionuclides- with their roots and accumulate them in large quantities within their stems and leaves these plants have to be harvested and disposed of as special waste. (Kühl, 2010)
2. **Phyto-Degradation:** Plants take up and break down contaminates through the release of enzymes and metabolic processes such as photosynthetic oxidation/ reductions. In this process organic pollutants are degraded and incorporated into the plant or broken down into the plant or broken into the soil. (Kühl, 2010)
3. **Phyto-Volatilization:** Some plants take up volatile contaminates and release them into the atmosphere through transpiration. The contaminate is transformed or degraded within the plant to create a less toxic substance before and then is released into the air. (Kühl, 2010)

4. **Phyto-Stabilization:** Some plants can sequester or immobilize contaminants by absorbing them into their roots and releasing a chemical that converts the contaminate to a less toxic state. The mechanism limits the migration of contaminate through water erosion, leaching, wind, and soil dispersion. (Kühl, 2010)

These four processes are used to clean up soils in with different contaminants using different types of plants. Some plants are good at taking up metals but cannot degrade inorganic chemicals, while with other plants it is the opposite. It is important to properly research the types of contaminants and what plant is the best fit to clean them. The two most common forms of phyto-remediation used for decontaminating dredge are phyto-extraction, because heavy metals are typically found in dredge material, and phyto-stabilization which is best at taking up natural chemicals such as arsenic and other organic compounds. By using phyto-remediation in targeted areas to clean degraded dredge material combined with other methods it is possible to cheaply clean up moderately contaminated materials.

Sediment Washing

In the past 50 years the standard was to leave the contaminated material in the CDF and capped it creating a new brownfield site. Two fairly new process have become more popular over the past decade, one called sediment washing and the other thermal destruction. Sediment washing is a process that uses both chemical and mechanical means to clean both organic and inorganic contaminants from the dredged material.

This process is cheap compared to many other traditional methods of cleaning contaminated soil and only costs \$40 to \$200 per ton and uses a mobile system that is operated by only a few men. “The only by-products [of sediment washing] are the wastes removed from the soil, treatable water, and biologically active soil suitable for on-site backfill.” (Biogenesis) First the material is taken in by barge or piped in from the dredge site. It is then sifted through large screens to separate large materials that may have been taken up with the material. The first step is to put the material into a large tank with a chemical slurry which contains cleaning agents, the material is then washed with a high power jet hose. This step is called called the preprocessor phase.

“Preprocessor Unit separates and homogenizes sediment particles in a contaminated slurry feed. It works with the other equipment in the BioGenesis Sediment Washing Process and forms the first step in the cleaning process...The Preprocessor uses high pressure collision forces to break apart individual sediment particles and suspend them in a slurry.” (Biogenesis) The next step in the process is aeration. The constant agitation of the material using high powered bubblers allows for the chemicals to penetrate the soil and allows for the separation of contaminants from the dredged material. The next step in the process is dewatering of the slurry , the waste water is slowly removed and treated using standard water treatment techniques. “Once the contaminants have been transferred to the liquid phase, the slurry is dewatered and the contaminated liquid treated using standard water treatment techniques. The cleaned and dewatered sediment solids can then be used for a variety of beneficial uses including wetlands restoration, top soil applications, industrial coatings, fillers, and capping material.” (Biogenesis) This process is one of the most effective and cheap ways to

clean degraded dredge materials. It is also one of the most environmentally beneficial because most of the material can once again be used as an organic soil. As this practice becomes more widely used, contaminated dredge material will once again become an excellent fill material for a variety of projects and uses instead of being stored and capped like the past 100 years.

Thermal Destruction

Thermal destruction of contaminated dredge material is one of the most effective ways of removing pollutants from soil. This process uses high heat to cleanse the soil of contaminants. "Thermal destruction is a treatment that uses high temperature oxidation under controlled conditions to degrade a substance into products that generally include gases, vapors, and ash. The most common incineration technologies applicable to the treatment of dredged material slurries include rotary kiln, fluidized bed, and multiple hearth." (Contaminated Marine Sediments: Assessment and Remediation, 1989) This process is very expensive due to the low combustibility of the material as well as the high cost of fuel to create the high heat. The technique is best used for very highly contaminated sites that would not be able to be cleaned through mechanical or chemical means. The by-products of this process (i.e. ash) can be made into a variety of products such as concrete, glass or other ceramics such as tiles. This is done using "A rotary kiln (at 1400°C) is used to melt a mixture of sediments (from dredging) and modifiers to form a cement matrix of calcium-alumino silicates. The melt is then pulverized and mixed with additives to make Construction-grade cement." (Stern) The high demand for concrete helps offset the high cost of fuel needed for the process

because the end product of this process is a necessary part of any cement mixture. By using the incinerated materials in cement or other ceramic products, left over contaminants are locked in the ceramics and cannot leech into the environment. This process is not the best method if one is concerned about the environment due to the waste that is created, especially the vapors that are released into the atmosphere. Thermal destruction of dredge material is one of the most effective ways to remove contaminants from highly degraded soils. In the future this process will become more necessary as we need to remove highly contaminated sediment to improve water quality and overall health of the environment.

Conclusion

In the future dredging will become more important as water levels in navigable channels (in rivers and oceans) drop and as ships get larger and larger. We as designers will need to invent new cheaper and more efficient ways of decontaminating soils. We will need to find more ecologically friendly methods of fixing the problems we have created. We are just now beginning to figure out what needs to be done and how. By using methods such as phyto-remediation, sediment washing, and thermal destruction we are able to get rid of certain unwanted materials. We are now beginning to find the best fit methods to clean and re-use these materials depending on the amount of contaminants present. As we better understand how to remediate soils dredge material will become more useful in new construction and habitat reconstruction. Dredge material has been an integral part of the city, many cities are built on top of it, but over the past century we have put it to the side (think out of sight out of mind). Thankfully new techniques are

once again making dredged material a useful tool in new construction and rehabilitating degraded ecologies.

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