In-situ construction of a semi-permeable sand/clay/organoclay layer as a component of a ground-water system for an anaerobic biocell treating organochlorine pesticides in soil

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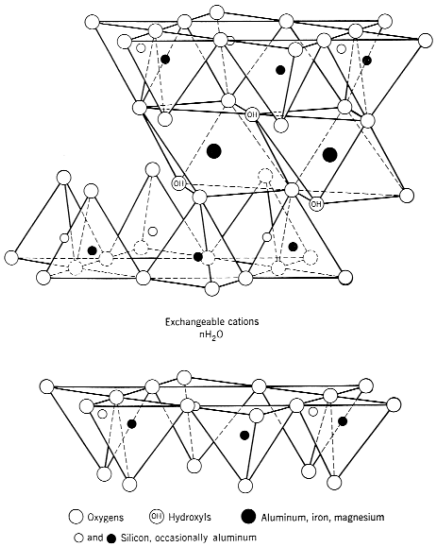
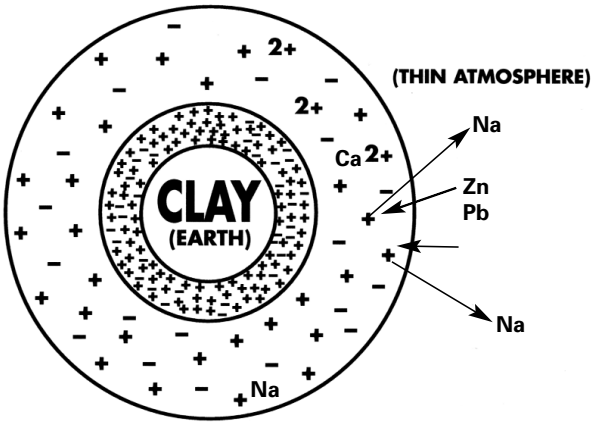
A comprehensive remedy was implemented for approximately 29,000 tons of pesticide-contaminated soils which included excavation, on-site containment, engineering controls and land-use restrictions at a site in North Carolina. The remedial strategy also included an "at-risk" anaerobic bioremediation component which involved pre-treatment of the soils placed in the containment cell using a combination of solid and liquid amendments designed to simultaneously stimulate anaerobic reduction and oxidation processes to reduce the residual pesticide levels (Hince et al., U. Mass Soils Conference, 2005). Permeable sorption barriers were constructed as groundwater-protection components of the biocell. The lower barrier was constructed by amending native coarse-sand and gravel soils with a 3:1 mixture (weight/weight) comprised of 116,000 lbs. of montmorillonite and 40,000 lbs. of a proprietary "organoclay" specialty filtration media (Biomin, Inc.). The montmorillonite removes leaching heavy metals by ion exchange, as well as lowers the permeability. The clay materials were mechanically incorporated into the upper six inches of native soils and compacted to achieve a permeability estimated to be on the order of from 1×10^{-5} to 1×10^{-6} cm/sec (substantially lower than estimated "native" permeability of about 1×10^{-2} cm/sec). The clay minerals within the sorption barrier provide a selective capacity to adsorb more than 2 x 1010 mg of pesticides, an amount 10 times greater than the total mass of pesticides present in the soils prior to treatment. A laboratory trial showed powdered organoclay to be very effective in the removal of pesticides such as alachlor, diazinon, metolachlor, 2,4-D, trifuralin, 2,4,5-T, and others from water. Scientific literature further supports these results, i.e. organoclays remove acidic herbicides and pesticides. Based on calculations of estimated leak rates through the overlying geosynthetic clay liner (GCL), the clay-amended sorption barrier would provide protection for an estimated 7 x 107 years against pesticides leaching at concentrations approaching their maximum solubility.

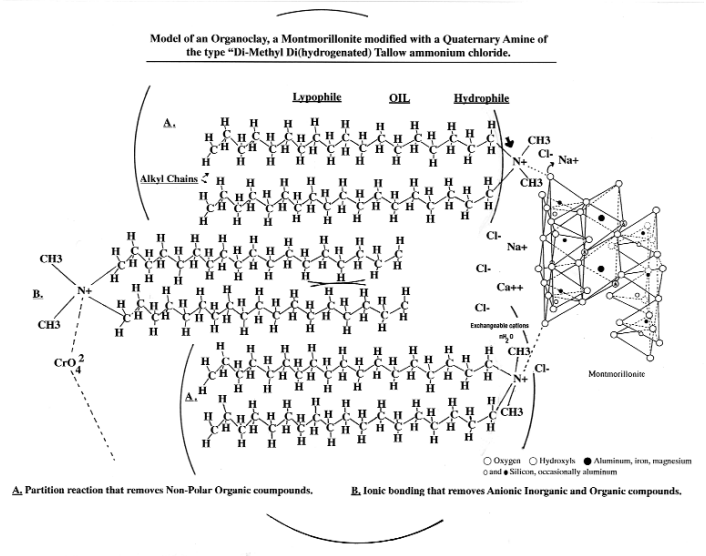
A BentomatTM SDN geosynthetic clay liner (GCL) was installed immediately above the clay-amended sorption barrier (CETCO Lining Technologies). BentomatTM SDN consists of a layer of sodium bentonite between two sheets of non-woven geotextile fabric. The GCL was installed immediately above the clay-organoclay sorption barrier, around the sides of the biocell and anchored into clean soil berms surrounding the biocell to provide further containment and long-term groundwater protection. Aside from the obvious protective benefits provided for by the GCL, the primary function of the GCL is to slow the rate of fluid flow through the overlying peat-amended biofiltration layer and hence to greatly increase the residence time of pore-water fluids in the biofiltration layer. The biofiltration layer is comprised of a mixture of >2,300 cubic yards of clean and low-pesticide-concentration soils (i.e., ± 0.5 - 10 mg/Kg) blended with >248,000 lbs. of aged peat. The peat-amended soils comprising the biofiltration layer were processed in a power screen and emplaced on the surface of the GCL via a mechanical conveyor system. The final installation of the biofiltration soil layer resulted in a ± one-foot thick lift immediately above the GCL. The amount of aged peat incorporated into the biofiltration layer provides a selective capacity to adsorb more than 9 x 1010 mg of pesticides, approximately 90 times the total mass of pesticides present in the soils prior to treatment. Based on calculations of estimated leak rates through the underlying GCL, the peat-amended biofiltration layer would provide protection for more than 2.5 x 108 years against pesticides leaching to groundwater. The combination of the clay-amended sorption barrier, Bentomat GCL and peat-amended biofiltration layer provide a total selective capacity to adsorb more than 1.25 x 1011 mg of pesticides, (two orders of magnitude greater than the total mass of pesticides prior to treatment), and provide more than 3.5 x 108 years protection against the leaching of pesticides to groundwater.



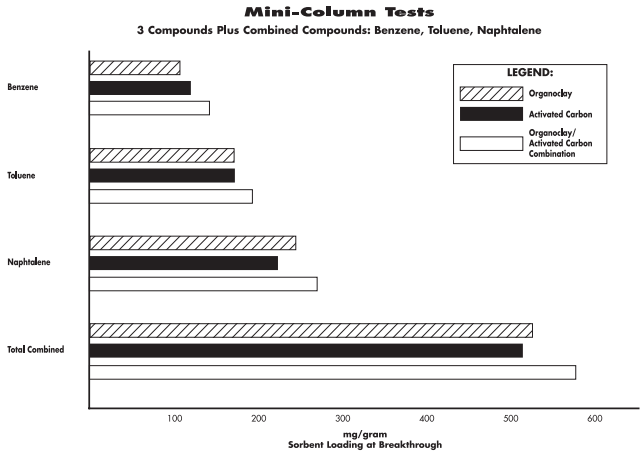
Montmorillonite Clay Structure



Diffuse double layer of a clay particle (location where heavy metals are ion exchanged onto the clay).

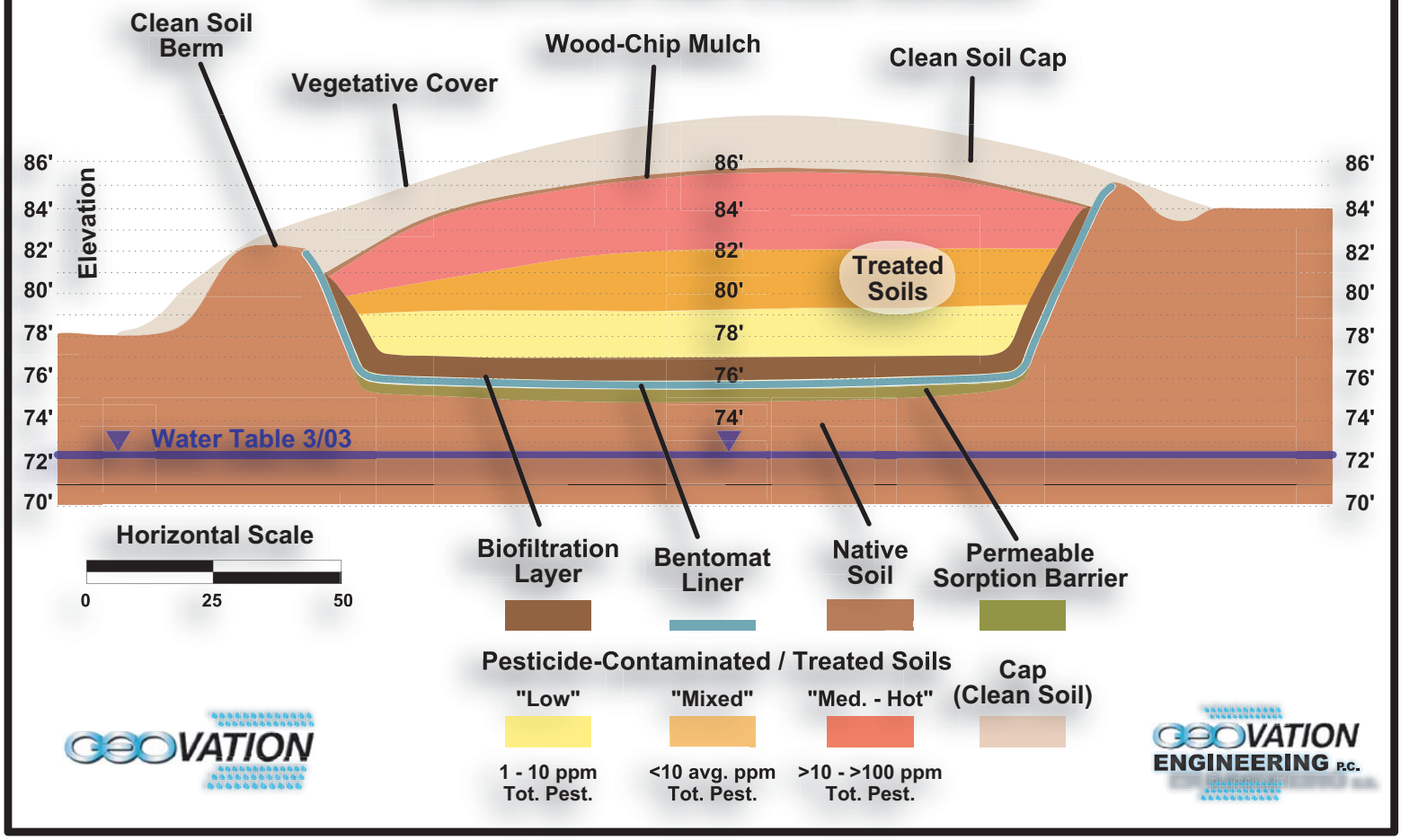


Model of an Organoclay



Mini-column tests showing the efficiency of organoclay for removing hydrocarbons from water, followed by activated carbon.

Containment Cell Cross Section



1. Spreading of clays for permeable sorbtion barrier

2. Compaction of clay-organoclay sorbtion barrier

3. Layout and installation of Bentomat GCL liner

4. Mixing, placement of peat-amended biofiltration barrier

5. Placement of clean-soil berms to anchor GCL

6. Nearly complete cell after placement of treated soils