Remediation of Explosives Contaminated Soils At Joliet Army Ammunition Plant via Windrow Composting

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ABSTRACT: During active periods, contamination of soils and sediments has occurred at Army ammunition plants and Army depots during production and handling of explosives such as 2,4,6-trinitrotoluene (TNT), octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) and methyl-n-2,4,6-tetranitroaniline (tetryl). The Joliet Army Ammunition Plant (JOAAP) is a former munitions production facility located on approximately 36 square miles (23,542 acres). The most cost effective and efficient methods of explosives contaminated soils remediation at JOAAP was determined to be a bioremediation process called windrow composting. It involves mixing the contaminated soils with organic matter (amendments) to promote degradation of the explosives. The amendments selected for use are corn processing waste, wood chips, and stable bedding. The compost blending ratio is 70:30 amendments:soil. The amendment portion of the compost is approximately 18% corn processing waste, 52% stable bedding, and 30% wood chips to obtain a the required carbon:nitogen (C:N) ratio and moisture level. At JOAAP, the process is accelerated by starting the microbial activity prior to mixing with contaminated soil. A 20-acre state-of-the-art facility capable of treating 40,000 tons of soil a year was constructed onsite at JOAAP to accomplish this. During its initial 4 months of operation, 14,000 tons of explosives contaminated soil have been successfully bioremediated. As the treatment process is refined, it is anticipated that over 50,000 tons can be treated in a year. In this paper, the success of windrow composting at JOAAP, the impact of improvisations on the treatment time and the lessons learnt will be presented.

Separate operable units were established for soil and groundwater at the Joliet Army Ammunition Plant to address the remediation objectives at the site. A total of 25 Soil Operable Units (SOU) were identified as requiring additional treatment for contaminated soils. The explosives in these operable units include dinitrotolouene (DNT), nitrotolouene (NT), trinitrobenzene (TNB), TNT, HMX, RDX and tetryl. The data on the existing levels of contamination and the remedial goals (RGs) for the individual contaminant of concern is provided in the Record of Decision (ROD) signed in 1998 (1). Based on pilot tests of various bioremediation technologies, windrow composting was selected as the preferred technology. This decision was based on several factors including cost technical feasibility, residence time and environmental acceptability.

Composting involves biological degradation or transformation of organic compounds by mesophilic and thermophilic microorganisms. As a result of this process, nitroaromatics are converted into non-toxic end products such as mono and di-amino toluene and carbon dioxide.

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The bioactivity factors such as oxygen, pH, nutrients, bioaugmentation, heterogeneity, mixing, temperature, water activity and addition of treatment chemicals are easily controlled in a compost pile. However, the control of microbial community structure and use of alternative electron acceptors is difficult.

Figure 1 is a schematic of the process from excavation to completion of treatment. A 20-acre state of the art facility capable of treating 40,000 tons of soil a year was constructed onsite at JOAAP. The bioremediation facility includes an untreated soil stockpile area designed to hold up to 80,000 cy of contaminated soil, a 1 million gallon contact water basin, a 24,000 ft^2 soil staging building, and 3 treatment buildings totaling over100,000 ft^2. The compost is formed in the treatment buildings by blending the soils and amendments together with a compost turner. The amendments increase the pososity, thereby augmenting the mass transfer of air to the bacteria. The compost blending ratio is 70:30 amendments:soil. The amendment portion of the compost is approximately 18% corn processing waste, 52% stable bedding, and 30% wood chips. Corn processing waste has a low carbon:nitrogen (C:N) ratio and a high moisture content. Wood chips are dry and have a high C:N ratio. Stable bedding is often dry with a high C:N ratio. The compost turner forms the compost into windrows approximately 380ft long, 25ft wide, and 10ft high. A windrow is considered in active treatment following its initial turning. The ALLU AS 38 compost turner straddles the windrow as it mixes the material from both sides into the middle of the windrow. The bladewheel in the center of the drum throws the compost behind the machine, aerating it and re-forming the windrow.

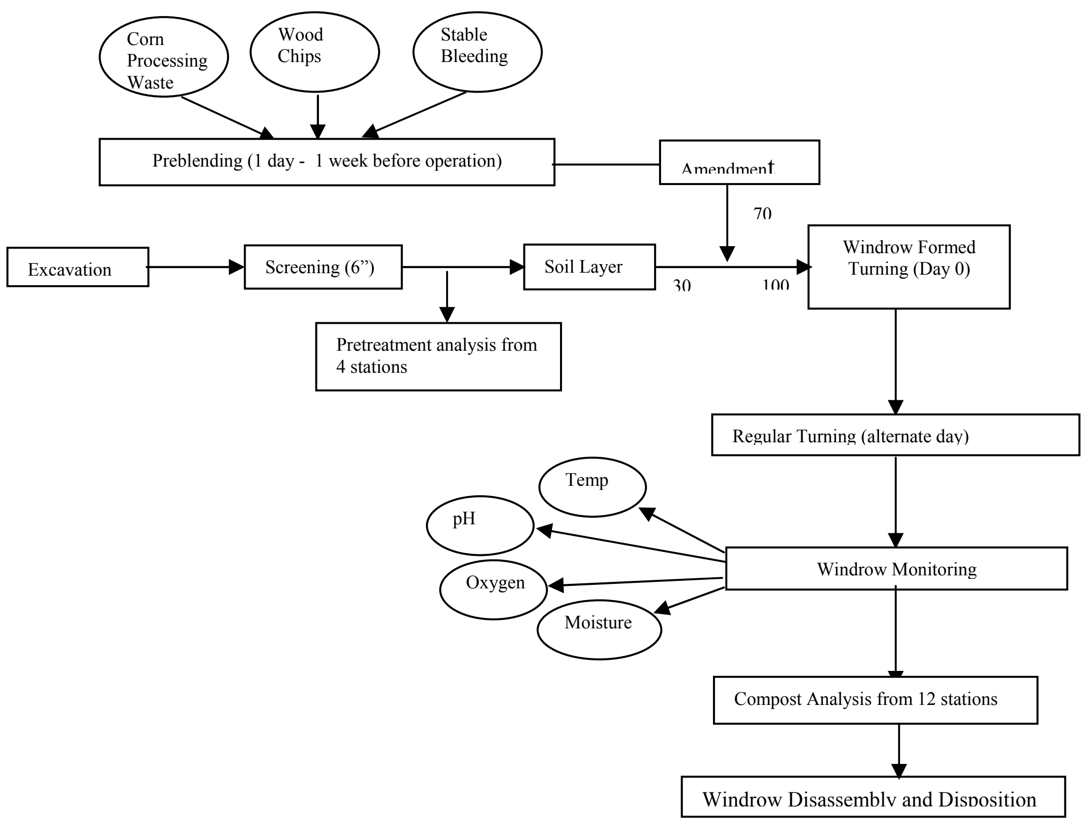

Figure 1. Process Flowsheet for Windrow Composting at JOAAP.

Figure 2 illustrates the kinetic data of the degradation of the explosive contaminants as obtained from the field study of windrow composting.

Approximately 800 tons of contaminated soils are treated in each windrow at a cost of approximately $84/ ton of soil. In the first seven months, 33 windrows have been successfully operated resulting in treatment of nearly 26,000 dry tons of contaminated soils. The failure rate of the windrows was 6.5 %. This rate dropped to 4.5 % on resampling.

As a result of pre-blending the amendments, the treatment time for the explosives reduced by over 20 % to an average of 17 days from 21 days. It was also observed that during winter, when the ambient temperature was subzero, the temperatures within the compost piles were around 30 ^{o}C. The moisture content was also maintained at 15- 20 %. This resulted in successful operation of the windrows during the winter months. The temperatures within the windrows during the summer months were around 60 ^{o}C.

In spite of the success of bioremediation at JOAAP, the process is not without problems. At present the screening of the soil is conducted with a 6-inch screen to remove rocks and debris to improve cost efficiency. However, smaller pebbles and pure explosives aggregates pasted with rock still pass through the screening process. The rocks and aggregate explosives do not undergo rapid degradation due to bioavailability limitations and result in a loss of overall efficiency. Thus, a smaller screen aided by a milling mechanism needs to be implemented to further improve the efficiency. In addition, for successful operation during winter months, it is necessary to turn the windrows despite the low ambient temperatures.

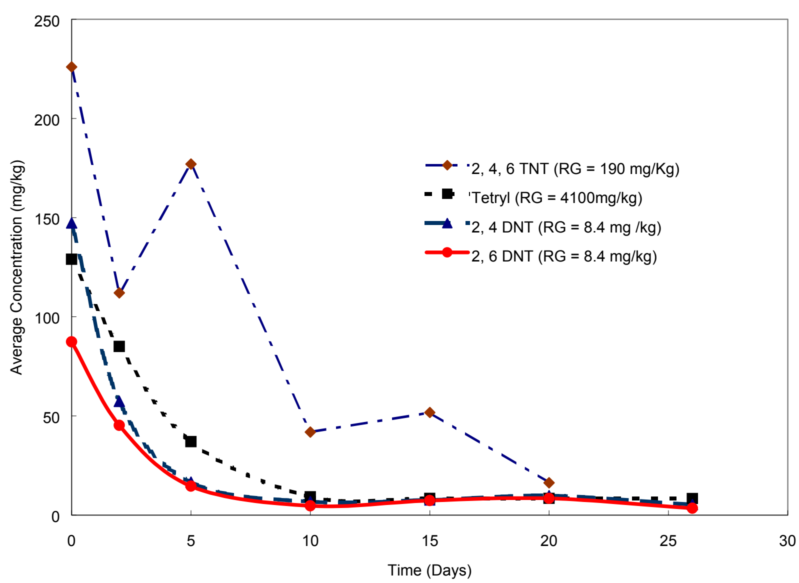

Figure 2. Change in Contaminant Concentration with days of operation obtained during field studies.

References

1) "Record of Decision for Soil and Groundwater Operable Units- Manufacturing and Load Assembly-Package Area-Joliet Army Ammunition Plant", US Army Corps Of Engineers, Louisville, November, 1998.