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Pilot-Scale Land Treatment Study at the Saginaw, MI, Confined Disposal Facility

PURPOSE: This technical note reports results from a pilot-scale land treatment study at the Saginaw, Michigan confined disposal facility (CDF) for dredged material. The study evaluated the technical feasibility of using land treatment technology to remediate dredged material contaminated with hydrophobic organic chemicals and to confirm results from a bench-scale study. This is the fourth in a series of technical notes on the feasibility of using low-cost and relatively passive biotechnology to reduce hydrophobic organic chemical concentrations in dredged material. The first technical note (Myers and Bowman 1999) described initial studies at the Milwaukee CDF. The second technical note (Myers and Williford 2000) provided an overview of bioremediation technologies that show promise for practical application to hydrophobic organic compounds in dredged material. The third technical note (Myers et al. 2003) described remediation of dredged material using composting technology.

BACKGROUND: Many Great Lakes dredged material CDFs are nearing capacity. Since it is expensive to site, design, and construct new CDFs, alternatives to traditional CDF disposal of dredged material are needed. To address this need, the U.S. Army Engineer District, Detroit (CELRE) and the Dredging Operations and Environmental Research Program (DOER) partnered to test the feasibility of using land treatment technology to bioremediate dredged material in CDFs. The larger objective is to convert CDFs from perpetual containment facilities to storage and treatment facilities. If contaminated dredged material can be cost-effectively cleaned to satisfy requirements for beneficial use, perhaps the service life of CDFs can be extended by treating, removing, and beneficially using dredged material.

Land treatment is a bioremediation technology in which contaminated soils are turned, i.e. tilled, and allowed to interact with the climate at the site (Myers and Williford 2000). Processes by which land treatment can potentially remove hydrophobic organic chemicals from dredged material in CDFs include photolysis, volatilization, and biodegradation (Myers 1996). Several bench-scale studies have shown that polychlorinated biphenyl (PCB) concentrations in sediment can be substantially reduced using land treatment technology (Tang and Myers 1998, Sayles et al. 2001, Tang and Myers 2002). Laboratory studies have also indicated that polycyclic aromatic hydrocarbons (PAHs) in sediment can be reduced using land treatment technology (Sayles et al. 2001). Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), however, have been resistant to land treatment technology in bench-scale studies (Myers and Tang 1998). The processes responsible for PCB and PAH removal in the bench-scale studies are not well understood, but a combination of volatilization and biodegradation seems most likely. The stability of PCDDs and PCDFs that has been reported for land treatment of sediment is unexplained given the tendency of PCBs to disappear from the same sediment under the same experimental conditions.

Bench-scale studies conducted in the laboratory generally do not simulate the myriad of climatic factors that are important components of land treatment technology. These factors drive the critical natural processes responsible for contaminant reduction, and for this reason, land treatment efficacy is very site-specific. It is necessary therefore to follow bench-scale laboratory studies with pilot-scale studies conducted in the field in order to confirm treatment observed in the laboratory and evaluate operational parameters. The pilot-scale field study described in this technical note was previously reported by Tang et al. (2000). This technical note summarizes that information and develops the comparison of pilot-scale to bench-scale data in more detail.

MATERIALS AND METHODS: Sediment was mechanically dredged from the Saginaw River and placed in three unlined test cells shown in Figure 1. Each test cell was 9.1 m (30 ft) in diameter and 0.91 m (3 ft) in depth. Dredged material was placed to a depth of 0.76 m (2.5 ft). One cell was used as a control. Dredged material was simply placed in this cell and left alone except for sampling. The other two cells were tilled on a biweekly basis (Figure 2). One of the tilled cells was also flooded with water from Saginaw Bay on a biweekly basis. Additional details of the cells are available in Tang et al. (2000).

Figure 1. Test cells on the Saginaw CDF, Bay City, MI

Immediately after filling on 2 September 1998, the test cells were sampled on a biweekly basis until the middle of November 1998. The test cells were again sampled from the middle of August 1999 through the middle of September 1999 on a biweekly basis. In the interval between the sampling events in November 1998 and August 1999, the cells were allowed to rest, i.e., no tilling or flooding. On each sampling event, a composite sample was collected by mixing seven random cores. The cores were taken from the surface to a depth of 16 cm (the tilled depth). Three composite samples from each cell were collected during the first sampling event (2 September 1998), and two composite samples were collected from each cell during the next five sampling events (mid-September to mid-November 1998). In the 1999 sampling, five composite samples were collected from each cell. Samples were analyzed for TCDDs, PCDFs, PCBs, water content, and total organic carbon (TOC).

On average, the dredged material as placed in the test cells had the following properties: specific gravity of 2.69, water content (weight of water/weight of dry solids) of 0.76, and a TOC concentration of 2.55 percent. The dredged material was 32 percent sand, and the remainder was silt.

Figure 2. Garden tiller used to till the experimental cells on a biweekly basis

SUMMARY OF PILOT-SCALE RESULTS: Tang et al. (2000) found that pilot-scale land treatment of Saginaw River dredged material resulted in a 70-percent reduction in PCBs and virtually no reduction of PDDDs and PCDFs. The differences between initial and final PCB concentrations are shown in Figure 3. The PCB concentrations shown in Figure 3 are total PCB concentrations obtained by summing PCB congeners.

Interestingly, there was no difference among control, tilled, and tilled and flooded cells. Most of the reduction in PCB concentrations occurred in the first 30 - 45 days. This is shown in Figure 4.

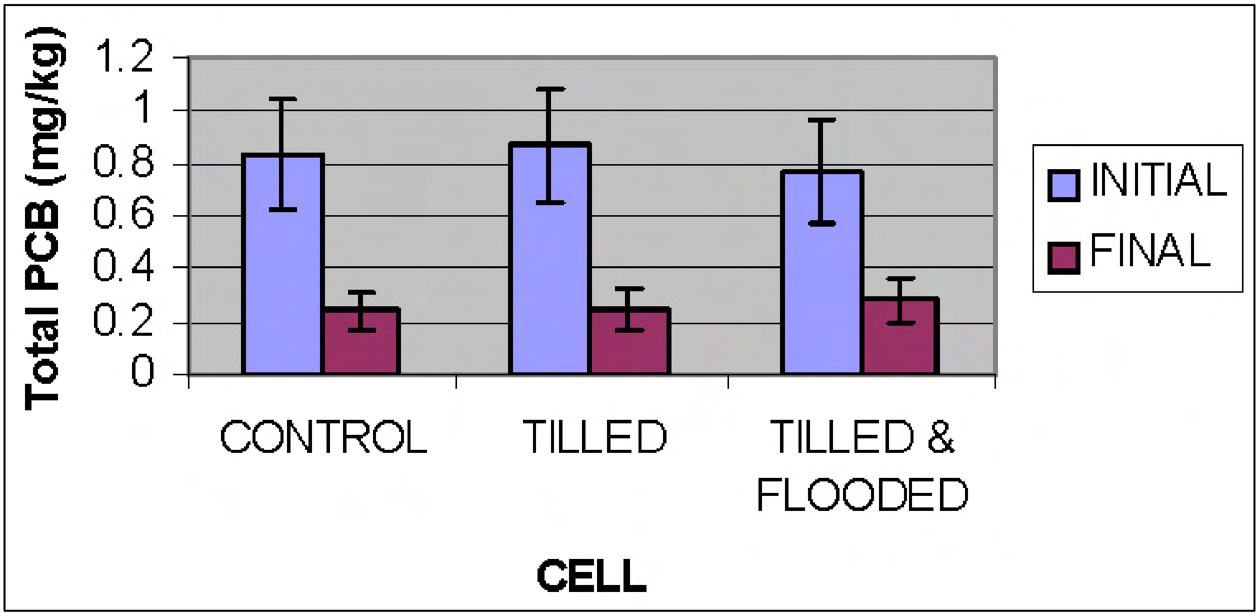

Figure 3. Initial and final total PCB concentrations in test cells at the Saginaw CDF

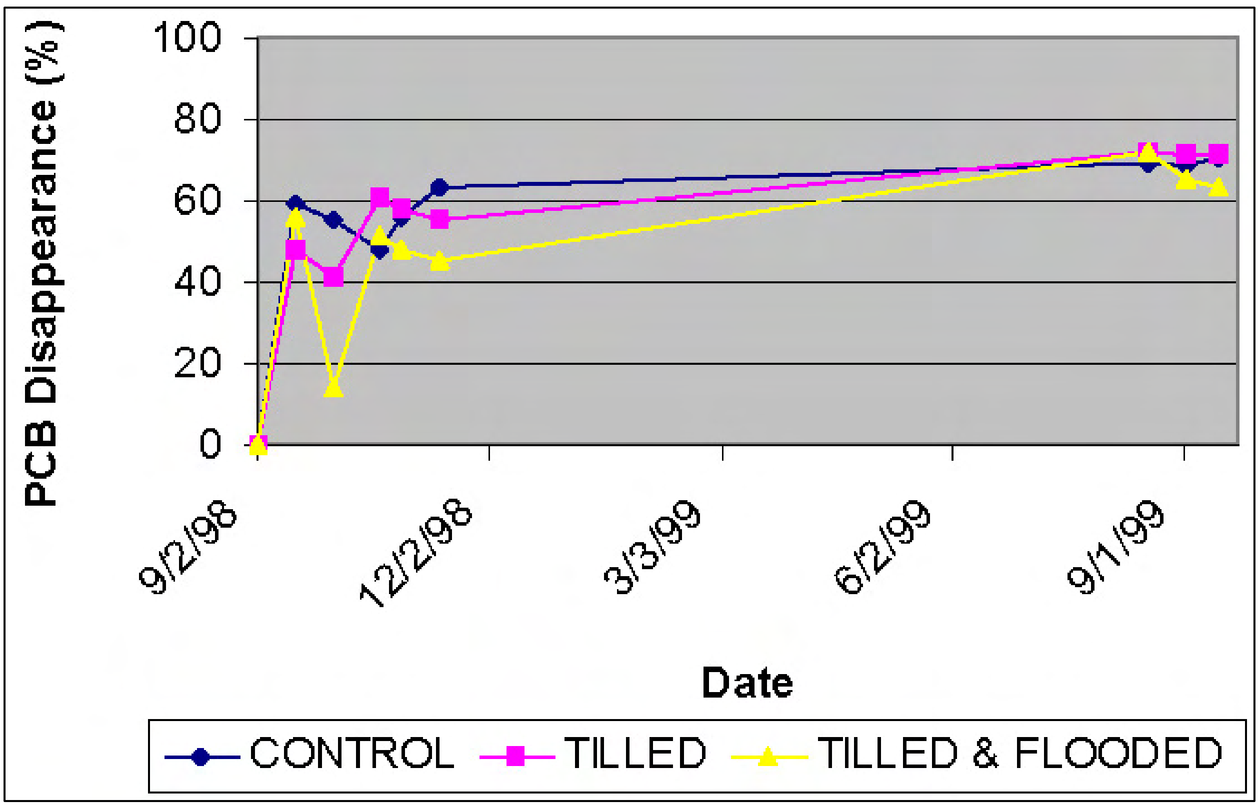

Figure 4. PCB disappearance over time in the pilot-scale cells

Figures 5 and 6 show initial and final PCDD and PCDF concentrations, respectively, in the pilot-scale test cells. PCDD and PCDF concentrations were actually higher at the end of the test than at the beginning. The increases in PCDD and PCDF concentrations occurred over the first

10 weeks of the study (Tang et al. 2000). No specific conclusions could be drawn from the data other than PCDDs and PCDFs in Saginaw River dredged material appear to be resistant to land treatment.

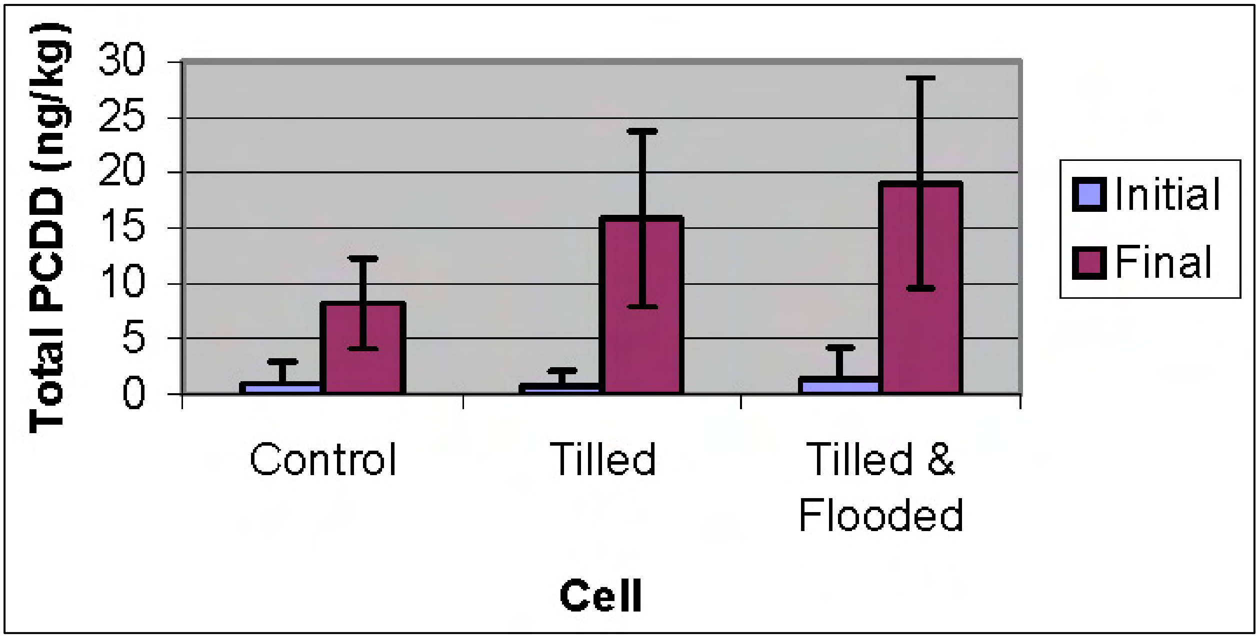

Figure 5. Initial and final total PCDD concentrations in test cells at the Saginaw CDF

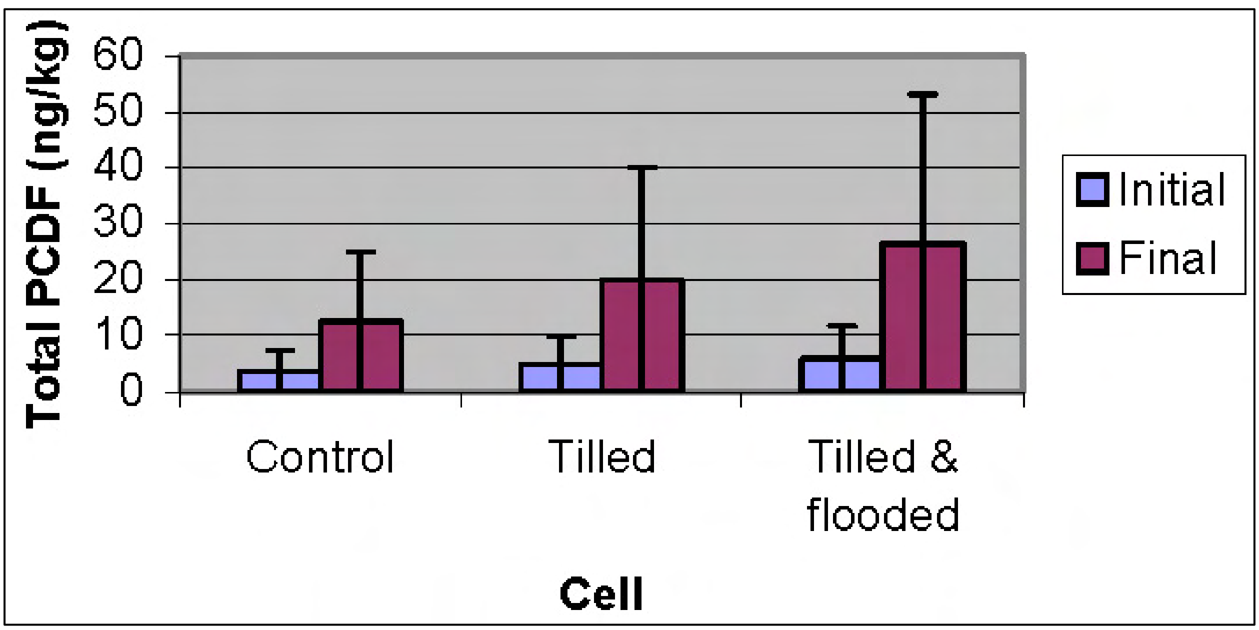

Figure 6. Initial and final PCDF concentrations in test cells at the Saginaw CDF

COMPARISON OF BENCH- AND PILOT-SCALE STUDIES: Bench-scale land treatment studies on Saginaw River sediment were conducted by Myers and Tang (1998) and Tang and Myers (1998). These studies were conducted in glass aquariums with dimensions of 64 cm X

64 cm X 25 cm (Figure 7). Initial and final total PCB concentrations over a 4-month period are shown in Figure 8.

The bench-scale study indicated that PCBs in Saginaw River sediment could be reduced with land treatment technology, and the pilot-scale data confirmed this finding. There were differences in the extent of reaction (percent PCB removed) with the bench-scale data showing less treatment than the pilot-scale data. This difference is probably attributable to site-specific conditions that were not simulated in the laboratory such as diurnal temperature cycles, wind, and sunlight. The bench-scale study also showed little difference in treatment efficiency among test cells. The pilot-scale study confirmed this observation, but the implications are not fully understood.

Initial and final total PCDD and PCDF concentrations over a 4-month period are shown in Figures 9 and 10, respectively. The differences in initial and 4-month PCDD concentrations were not statistically significant (Myers and Tang 1998). However, initial PCDF concentrations were statistically different from the other concentrations at the 0.1 level of significance, although the reductions from initial concentrations were small. There were no statistically significant differences between tilled and tilled and flooded cells. Thus, the bench-scale study showed that PCDDs and to a lesser extent PCDFs were resistant to land treatment technology. The pilot-scale study confirmed the stability of PCDDs and showed that the small decrease in PCDF concentrations in the bench-scale study were not significant at pilot scale.

DISCUSSION: The pilot-scale land treatment study at the Saginaw CDF showed that the bench-scale land treatment tests correctly indicated that PCBs in Saginaw River sediment can be reduced using land treatment technology and that PCDDs and PCDFs in Saginaw River sediment are resistant to land treatment technology. Thus, bench-scale studies can indicate the feasibility of using land treatment technology to reduce hydrophobic organic chemical concentrations in dredged material. This finding has important consequences for sites where bench-scale studies have indicated that land treatment of sediment is technically feasible, e.g. the bench-scale land treatment studies conducted on sediment from the Kinnickinnic River, WI (Sayles et al. 2001) and from New York/New Jersey Harbor (Tang and Myers 2002).

The bench- and pilot-scale tests showed no difference between treatment effects (experimental cells) and the control. This is a rather interesting finding for which there is no explanation. The implications of the control cells in the bench- and pilot-scale studies are that PCBs are probably slowly disappearing from the surface layer in the Saginaw CDF, PCDFs may or may not be slowly disappearing, and PCDDs are probably stable. The studies described in this technical note were short-term studies, and long-term predictions about PCB disappearance and PCDD/PCDF stability will require additional study.

CONCLUSIONS: Laboratory land treatment simulators can reliably predict land treatment effectiveness in the field. PCBs in dredged material are amenable to land treatment in CDFs, but PCDDs and PCDFs are resistant to land treatment and will require more aggressive treatment processes than those provided by land treatment for contaminant reduction.

Figure 7. Bench-scale land treatment aquariums

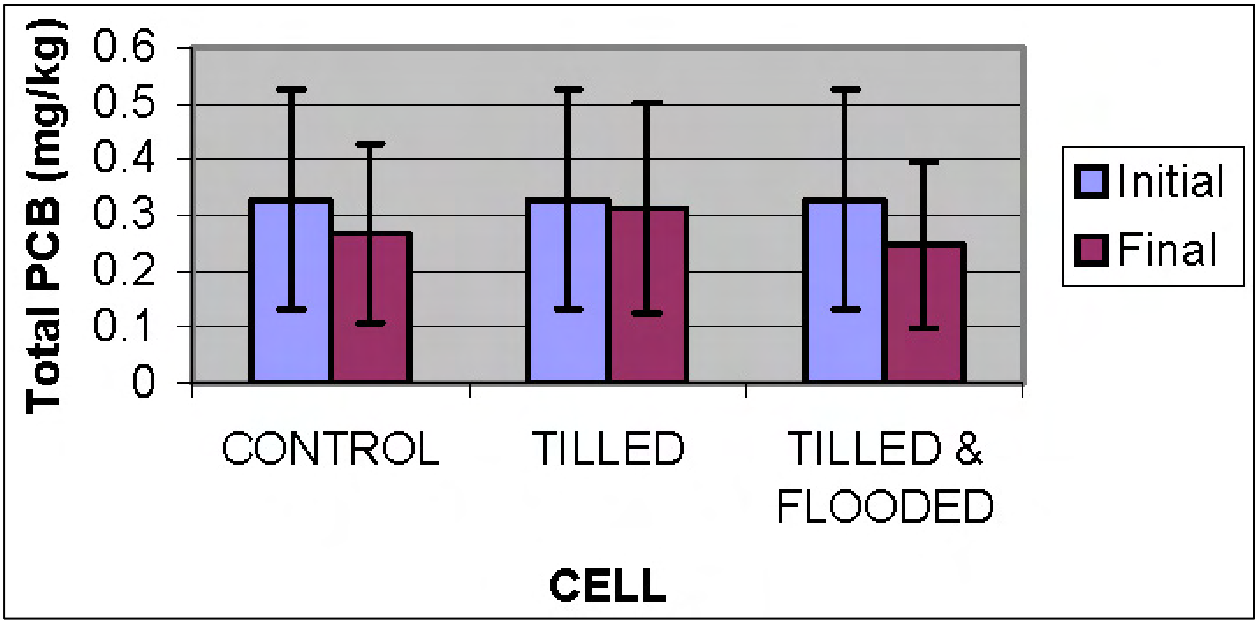

Figure 8. Initial and 4-month total PCB concentrations in bench-scale cells

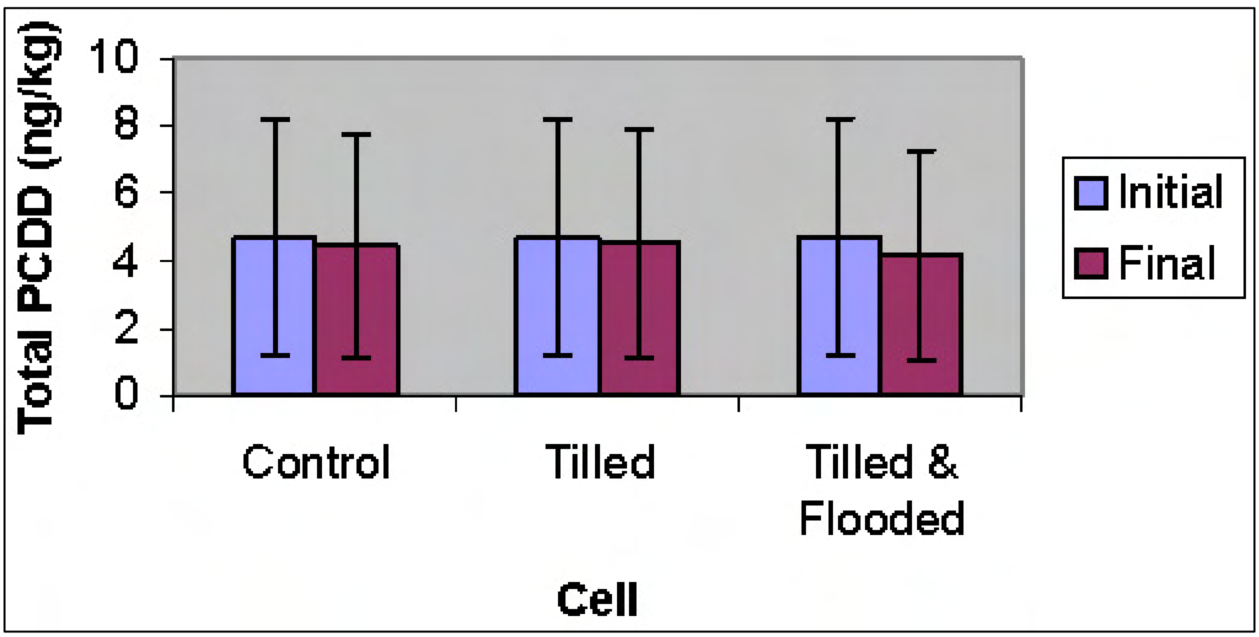

Figure 9. Initial and 4-month PCDD concentrations in bench-scale cells

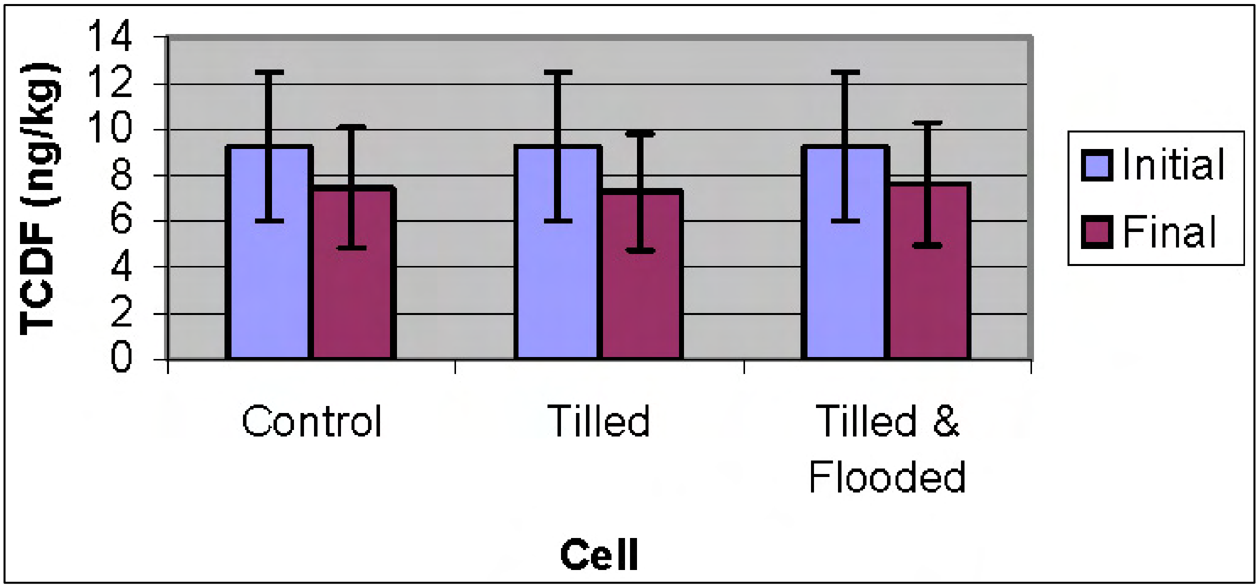

Figure 10. Initial and 4-month PCDF concentrations in control and tilled bench-scale cells and initial and 2-month PCDF concentrations in the tilled and flooded cell (no data for 4-month tilled and flooded cell)

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> Myers, T. E., and Horner, P. (2003). " Pilot-scale land treatment study at the Saginaw, MI confined disposal facility," *DOER Technical Notes Collection* (ERDC TN-DOER-C35), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.erdc.army.mil/el/dots/doer*

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