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Impact of spent engine oil on soil and the growth of *Zea mays* seeds

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ABSTRACT

The impact of waste engine oil on soil and the growth of *Zea mays* seeds were investigated in this paper. Three concentrations of 500mL, 1000mL, and 1500mL waste engine oil applied to the soil affected the soil and growth of *Zea mays* seeds. The p^H of soil increased from 6.0 (control) to 6.7 (1500mL), moisture content decreased significantly [p<0.05] from 12.0 to 10.9%, while phosphorus decreased significantly [p<0.05] from 35.0 to 20.0 mg/kg. The reductions in the measured parameters were significant at [p<0.05]. Potassium decreased from 0.20±0.01 to 0.18±0.06 umol/kg, magnesium from 2.80 ±0.02 to 1.80±0.01umol/kg, and calcium from 7.40±0.04 to 6.24± 0.01 umol/kg. Germination of the seed, growth rate and leaf spread were also delayed. This study showed to a great extent that spent engine oil affects vegetative land and suggests that plants could be used as bio-indicators of pollution in oil producing and oil spillage prone areas of the Niger Delta of Nigeria.

1. Introduction

The environmental impacts associated with the exploration and exploitation of crude oil has been a popular area of experimental research and concern the world over. Pollution from spent engine oil is also one of the most serious environmental problems in most part of the world especially developing nations like Nigeria where it is even more widespread than crude oil spillage and pollution, due to improper disposal methods. Oil spills are most often caused by accidents involving tankers, barges, pipelines, refineries, and storage facilities during the transportation of the oil (Ginsbury *et al*., 1993; Okoko and Ibada, 1999). Oil spills can have serious impacts. At low temperatures, oil tends to persist for long periods of time because of the low rates of evaporation (Amundu *et al.,* 1987). The frozen ground prevents the oil from seeping in, and this makes it travel for long distances (Amundu and Omole, 1993a).Oil spills account for only 12% of all sources of oil pollution. The major cause of ocean oil pollution is industrial waste (61%). Tanker accidents contribute 5% and tanker operation account for 7% (Wade, 1990). Another problem with oil pollution is the dumping down a drain or driveway. This can easily get into water systems (Kimura *et al.,* 1989; Ency, 1998).Pollution from spent engine oil is one of the most serious environmental problems in most part of the world, especially developing nations like Nigeria, where it is even more widespread than crude oil spillage and pollution (Nwankwo and Ifedi, 1988; NDES, 1999).

Engine oil is a blend of base oils and performance enhancing additives. It is the non-volatile fraction of crude oil obtained by the vacuum distillation of crude oil (Adams and Jackson, 1996). Crude oil is a complex mixture of thousands of hydrocarbons and non hydrocarbon compounds, including heavy metals (Overton *et al.,* 1994). Although the toxicity of each individual component is known, the toxicity of complex mixtures such as crude oils and refined products is extremely difficult to assessThe oil in an engine does more than just reduce friction between its moving parts; it helps to seal the high- pressure combustion gases inside the cylinders to impede the corrosion of metal parts, absorb some of the harmful by- products of combustion, and transfer heat from one part of the engine to another. It usually contains additives such as amines, phenols, benzene, calcium, zinc, barium, magnesium, phosphorus, sulfur, and lead (Kalischevsky and Peters, 1960; Onojake, 2004).The spent engine oil or lubricant is usually obtained after servicing and subsequent draining from automobile and generator engines. Nigeria alone accounts for more than 87 million liters of spent lubricant annually (Nwankwo and Ifedi, 1988; NDES, 1999). Adequate attention has not been given to its proper disposal (NDES, 19990).

Spent engine oil has been implicated in certain physiological and morphological aberrations in plants (Amundu and Omole, 1993b). This is due to its phytotoxic effects on plants, causing severe injuries leading to the yellowing and shedding of leaves and delaying fruit maturation (Atuanya 1987).

The soil is the part of the earth which supports animals, plants and microbial life and thus owes nutritional duties to them (Baker, 1970). Oil spillage in agricultural lands and other ecosystems are widely reported (Bazbaruah *et al.,* 1994]. The impact of petroleum prospecting and producing operations on the environment has produced ecological problems of great magnitude (Bossert and Bartha, 1984). When the soil is polluted by oil, the effects range from blanketing of the soil to the displacement of pore spaces in the soil. This modifies the rate of gaseous exchange and destroys soil texture, structure and microbial profile. (Cutforth *et al.,* 1985a). Cutforth *et al.,* (1985b) reported that crude oil penetrates and accumulates in plants, thus causing damage to cell membranes and leakages of cell content. Crude oil spillage on soil makes it unsatisfactory for plant growth. Bioassays such as measurements of seed germination and early seedling growth have been used to monitor treatment effects and restoration of oil-contaminated sites (Sverdrup *et al*., 2003; Sayles, 1999). This is due to insufficient aeration of the soil because of the displacement of air from the space between soil particles by crude oil. This leads to an increase in demand for oxygen brought about by activities of oil decomposing microorganisms (De Jong, 1980; Odu, 1987and Davies, 1996). The lower the quantity of water absorbed, the lower the temperature of the soil environment and the lower the rate of plant germination (Cutforth *et al.,* 1985b; Amundu *et al.,* 1987). Plants growing on oil polluted soils are retarded and chlorosis of leaves results, coupled with dehydration of plant which indicates water deficiency (De Jong,, 1980).

The maize plant (*Zea mays*) requires a temperature of 16^0C to 32^0C for proper growth. It is the cereal plant that thrives well in the tropical regions of the world. It has various industrial uses and has been found to be a major source of carbohydrate in the third world countries. Due to industrialization and urbanization, many mechanical works which lead to the spilling of waste engine oil abound (Udosen, 1992; Wills, 2000). These oils are dumped in open plots of lands, into sewers and drainage ditches. Small scale farmers and garden owners most often find their lands affected by this discarded waste engine oil. This indiscriminate dumping can lead to pollution of streams and rivers as well as underground waters via slippage and leaching (Odum, 1994). Pollution caused by the refined products such as waste engine oil and diesel has not been given the proper attention it deserves.

The effects of discharged engine oil are poorly understood as only limited data exist and are not readily available. The objective of the present study was to investigate the environmental effects of waste engine oil on soil and maize plant and hence use the maize plant, as a bio-indicator of pollution in oil producing areas of the Niger Delta region of Nigeria.

2. Materials and methods

This investigation was carried out between 4th April to 20th July, 2011.

2.1. Seeds

The maize seeds (*Zea mays*) (cv. Pride 1108) used in this study were obtained from the stores of the National Root Crops Research Institute, [NRCRI], Umudike, Umuahia, Abia State Nigeria. These viable seeds were used for this study because of their sensitivity to soil and water. They were taken in polyethylene bags to the Department of Plant Science and Biotechnology of Abia State University, for proper identification and screening before usage.

2.2. Land

The study site was an area of land in Aba. Aba is the commercial nerve centre of Abia State in the Southeastern part of Nigeria. Abia State is in the Niger Delta Area of Nigeria where all the oil exploration and exploitation activities are carried out (Ginsbury *et al.,* 1993; NDES, 1999). A plot of land measuring 16m by 16m was acquired for the purpose of this study. The plot of land was divided into four equal portions [8m x 8m] with one portion used as control. The soil type used for this study was the loamy sand soil, which contains about 85.8% sand, 9.4% silt and 4.8% clay. A total of five (5) study sites were used to make up for differences that could arise due to soil texture. After the preliminary soil analyses tests, three portions were deliberately contaminated with waste engine oil, 500mL, 1000mL, and 1500mL respectively. The appropriate amount of waste engine oil was randomly sprayed and thoroughly mixed with the top soil. After 24hrs, soil samples were randomly collected from these portions. This was done by removing litter from the predetermined area inside each portion of the land and thereafter using a trowel to take the soil from the surface (0-15cm) and sub-surface (15 – 30cm) (Black, 1965). These soil samples were put into polyethylene bags, labeled accordingly and taken to the laboratory for subsequent analyses. Each of the four test portions of land of contaminated soil had 16 seeds of cv. Pride 1108 maize seeds planted in 4 rows of 4 seeds on a row with 2m by 2m spacing.

2.3. Soil analysis

The P^H, temperature, moisture content, soil particle size, phosphorus, potassium, sodium, calcium, and magnesium content of the soils were analyzed using the conventional standard methods (Black, 1965; APHA/AWWA, 1985; AOAC, 1996).

2.4. Statistical analysis

Data collected were statistically analyzed for differences between individual plots by use of students't-test and simple percentages, followed by Fisher LSD test at 5%. Differences between test and control were considered significant for $p<0.05$.

3. Results and discussion

The physical and chemical characteristics of soil samples from waste engine oil contaminated and control sites are presented in Table 1. The results showed that there were changes in the physico-chemical parameters of the soil. The P^H of the soil increased significantly [$p<0.05$] from 6.0 ± 0.05 (control) to 6.7 ± 0.03 for (1500mL contaminated soil). Moisture content of the soil also decreased significantly [$p<0.05$] from 12.0 ± 0.01(control) to 10.9 ± 0.04%. for (1500mL contaminated soil).The results also showed a significant increase [$p<0.05$] in temperature from 27.0 ± 0.05^oC (control) to 30.0 ± 0.02^0C. for (1500mL contaminated soil). These results are consistent with the findings of Nwagwu and Okechukwu, (1981); Nwankwo and Irechukwu, (1981) who reported that during oil spillage, movement of oil into the soil results in soil/oil reaction which affects soil particle size; block air spaces hence increase temperature and pH.

Table 1
Baseline Analysis of Soil Sample after contamination with Waste engine oil.

Waste Oil (ml) (per 64m^2 plot)	pH	Tempt. (^{0}C)	Moisture (%)	Phosphoreuse (mg/kg)
0 (control)	6.0±0.05	27.0±0.05	12.0±0.01	35.0±0.02
500	6.2±0.02	28.0±0.04	11.8±0.03	28.0±0.03
1000	6.4±0.01	30.0±0.03	11.6±0.05	24.0±0.06
1500	6.7±0.03	30.0±0.02	10.9±0.04	20.0±0.03

*Values are mean ± SD of triplicate determinations.

Table 2 lists the mineral content of the soil. Potassium was reduced from 0.20 ± 0.01 to 0.18 ±0.06 umol/kg and calcium from 7.40±0.04 to 6.24±0.01 umol/kg. Sodium content was not affected. The results showed that, mineral salts of the waste engine oil contaminated soil are affected by the spent engine oil as they were all none significantly [($p<0.05$] reduced. These finding agrees with those of (Nyle *et al.*, 2000) who reported that the finer the texture of a soil, the greater is the effective surface exposed by its particles. Microorganisms tend to grow on and colonize particle surfaces, hence microbial reactions in soils are greatly affected by the specific surface area, which also affects the mineral content of the soil (Oudota and Dupont, 1993). Particle surfaces of minerals and water films between them tend to attract each other, sodium being monovalent was least attracted, hence it was not decreased like potassium, magnesium and calcium.

Table 2
Mineral content of Soil (umol/kg).

Waste oil (ml) (per 64m^2 plot)	Potassium	Sodium	Magnesium	Calcium
0 (control)	0.20±0.01	0.15±0.01	2.80±0.02	7.40±0.04
500	0.19±0.05	0.15±0.01	2.60±0.01	7.00±0.02
1000	0.19±0.04	0.15±0.02	2.00±0.01	6.00±0.01
1500	0.18±0.06	0.15±0.01	1.80±0.01	6.24±0.01

* Values are mean ± SD of triplicate determinations.

The maize seeds took 6 days for 500mL, 9days for 1000mL and 12days for 1500mL contaminated soil to germinate, which were significantly [$p<0.05$] reduced in the control which germinated in 3days, as shown in Figure 1. In the control (un-contaminated) soil all 16 seeds germinated, while for 500mL contaminated soil, 12 seeds, for 1000mL, 8 seeds and for 1500mL, only 4 seeds germinated. The number of seeds that germinated and the number of days it took the seeds to germinate in the three experimental sites were significantly [$p<0.05$] different compared to control. The results also showed that the spent engine oil may have made the soil unsatisfactory for plant growth, perhaps due to insufficient aeration of the soil because of the displacement of air spaces in the soil by oil.

The average heights of the plants were also affected as shown in Table 3. Whereas the control germinated and grew to 34.0 ± 0.06cm in 3 days, it took the 500mL waste engine oil contaminated soil plant 6 days to germinate and grew only to 20.3± 0.03cm, and 9 days for 1000mL waste engine contaminated soil plant to germinate and grew to 21.0 ± 0.04cm, while the 1500mL waste engine oil contaminated soil plant took 12 days to germinate and grew to 23.0±0.07cm. Using the student t-test for statistical analysis, the difference in growth heights was significant [$p<0.05$] compared to the control.

The number of days it took the maize plant leaves to appear was affected by waste engine oil treatment of soil as shown in figure 2. The leaves of the maize plants in the control plot appeared on the 6th day, while those of the contaminated soils did not appear until the 8th day for the 500mL, and 14th day for the 1000mL treatment. The leaves of plants on the 1500mL waste engine oil contaminated soil did not appear within the experimental period.

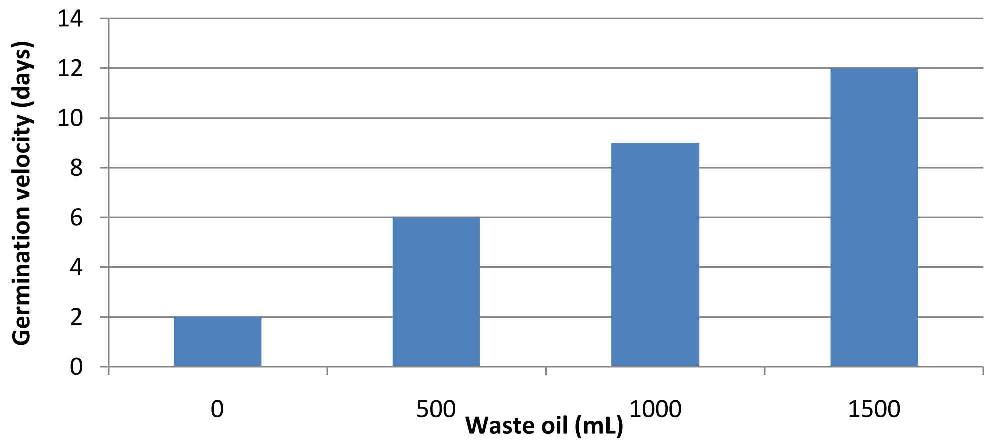

Fig. 1. Germination velocity of maize seeds on waste oil uncontaminated and contaminated soils.

Changes in the morphology of the plants were also observed as recorded in Table 4. While the control remained green and the root length reached 20.1cm after 12 days, the leaves and stems of plants on contaminated soils changed drastically from light green to pale yellow and had shorter root length.

Our findings agrees with those of (De Jong ,1980) who reported that oil causes color change in leaves, stems and affect the rate of root elongation. Aerial leaf appearance and spread is directly related to number of stomata (Baker, 1970); hence as concentration of spent oil increased, leaf color changed from light green to pale yellow.

The emergence of plant roots was controlled by the availability of water. The inability of the root to get enough water increased the stress on the root, which in effect reduced leaf growth through stomatal conductance (Baker, 1970; De Jong, 1980). These findings suggest that any stress on the root will have adverse effects on the plant leaf. Since uptake of water and salts (ions) were carried out by the roots, the untreated soil plants with roots undisturbed may have grown normally, while the treated soil plants did not. Cell disruption in roots and other organs may have occurred (Cutforth *et al*., 1985b).

Table 3
Height (cm) of maize plants at 12days after planting as affected by rates of spent engine oil contamination.

Waste Oil ((ml) per $64m^2$ plot)	**DAYS**									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
0(Control)	34 ±0.06	57.0 ±0.03	82.0 ±0.03	82.7 ±0.01	105.2 ±0.03	120.0 ±0.02	135.0 ±0.02	141.1 ±0.02	154.0 ±0.03	168.0 ±0.04
500				20.3 ±0.01	20.4 ±0.02	30.0 ±0.02	41.8 ±0.02	42.2 ±0.06	51.2 ±0.03	61.2 ±0.02
1000							21.0 ±0.04	25.3 ±0.04	28.6 ±0.02	30.6 ±0.01
1500										23.0 ±0.07

*Values are mean ±SD of triplicate determinations

4. Conclusion

The adverse effects noticed on spent engine oil treated soil plants may be due to unfavorable conditions created in the soil by the spent engine oil, resulting in drought conditions as well as non-availability of nutrients as shown by these results. We therefore suggest that waste engine oil from automobile and other sources should be properly disposed such that they would not constitute environmental problems vis-à-vis land pollution and its attendant effects on soil, plants and public health.

We also suggest that research into recycling of these spent engine oils should be encouraged and funded as this would go a long way in reducing the large volumes and check- mating the unhealthy disposal of these petroleum wastes. We also recommend strict disposal regulations and legislation's against irregular and reckless disposal of this environmental hazard. Plants such as *Zea mays* could therefore be used as biomarkers of pollution in oil producing and oil spillage prone areas like the Niger Delta region of Nigeria. *Zea mays* is a plant that thrives very well on soils of the Niger Delta region. This results show that the plant growth as well as the soil is affected by the spent engine oil.

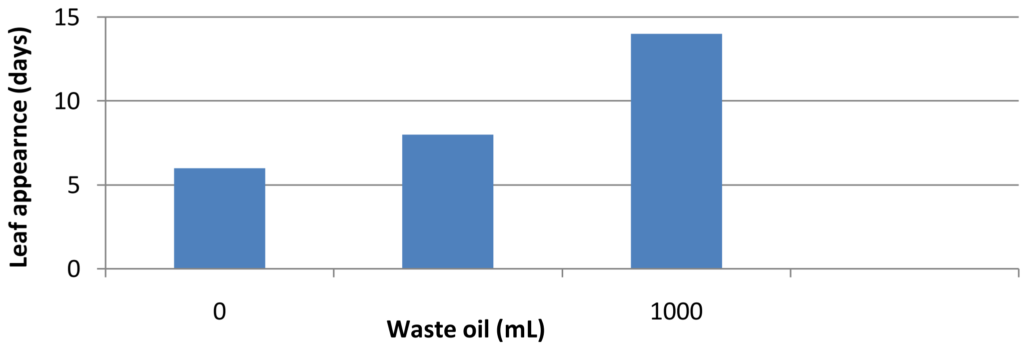

Fig. 2. Leaf appearance of maize plant on waste oil uncontaminated and contaminated soils.

Table 4
Effect of waste engine oil treatment on maize morphology.

Waste oil (ml) (Per $64m^2$ plot)	Leaf color	Stem color	Root length (cm)
0 (control)	Green	Green	20.1 $\pm$ 0.08
500	Green	Light green	12.0 $\pm$ 0.05
1000	Light green	Pale yellow	9.0 $\pm$ 0.07
1500	Pale yellow	Pale yellow	2.0 $\pm$ 0.06

*Values are mean ±SD of triplicate determinations

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References

Adam, S.P., Jackson, P.P., 1996. Bioremediation of Oil Spills. Theory of practice. Int. Bioremediation Ser. 11, 12-17.

Amundu, O., Omole, J.C., 1993a. Biological aspects of land rehabitation following hydrocarbon contamination. Environ. Pollut. 8, 107-112.

Amundu, O., Omole, J.C., 1993b. Effect of waste engine oil spillage on Physiochemical and Microbiological properties of soil. J. Sci. Res. Dev. 1, 61-64.

Amundu, O.O., Adebowale, A.A., Ugorji, E.O., 1987. Occurrence and characteristics of hydrocarbon utilizing Bacteria in Nigerian Soil contaminated with spent motor oil. Indian J. Soil Microbiol. 27, 63-87.

AOAC, 1996. Official Methods of Analysis. Association of Official Analytical Chemists. Washington DC P14. APHA/AWWA, 1985; Standard methods for the examination of water and waste water quality. J. Environ. Toxicol. Water qual. 11, 72-82.

Atuanya, E.I., 1987. Effect of waste engine oil pollution on physical and chemical Properties of soil: A case study of waste oil contaminated Delta soil. Nigerian J. Appl. Sci. 155-178.

Baker, J.M., 1970. The effect of oil on plants. Environ. Pollut. 1, 27-44.

Bazbaruah, R.H., Gogoi, B.K., Dilliai, K.R., 1994. Isolation and identification of Microorganisms involved in microbial desulphurization of Petroleum crude. Indian J. Microbiol. 34, 39-45.

Black, C.A., 1965. Methods of soil analysis. Amer. Soc. Agron. Madison, Wisconsin. Agronomy Part 2, No. 9.

Bossert, I., Bartha, R.I., 1984. The Fate of Petroleum in soil. Ecosystem In: Petroleum Microbiology; RM Macmillan, New York. 135-455.

Cutforth, H.W., Shaykerwich, C.F., Cho, C.M., 1985a. Soil, water-soil temperature Interactions in the germination and emergence of corn. (Zea mays L) Canadian J. Soil Sci. 66, 51-58.

Cutforth, H.W., Shaykerwich, C.F., Cho, C.M., 1985b. Effect of soil, water and Temperature on corn (Zea mays L). Root growth during emergence. Canadian J. Soil Sci. 66, 445-455.

Davies, T.M., Magnatus, C., Saurha, U.T., 1996. Isolation of petroleum depending bacteria from various soil samples. Petroleum Microbiol. 21, 17-20.

De Jong, E., 1980. The effect of crude oil spills on cereals. Environ. Pollut. 23, 187-196.

Ency, A.N., 1998. Effect of oil exploration and petroleum hydrocarbons utilization on water quality and fauna of Qua Boa river estuary., J. Aquatic Sci. 10, 43-52.

Ginsbury, P., Sterling, S., Gotheherer, S., 1993. The citizens' advisory council as a means of mitigating environmental impacts of terminal and Tanker operations. Marine Policy. 17(5), 404-411.

Kalischevsky, V.A., Peters, E.H., 1960. Petroleum, our man of all work; the raw Materials, crude petroleum and natural gas. In: Petroleum products Handbook. New York, Mcgraw-Hill Book Company. 1-22.

Kimura, B., Murakamin, M., Fujisaw, H., 1989. Characteristics and oil degrading Activities of oil degrading bacteria isolated from the sea water of oil polluted Bisan Seto and oil polluted Hibiki Nada. Bull. Japanese Soci. Scient. Fish. 58, 1081-1095.

NDES, 1999. Niger Delta Environnemental Survey. Phase 1 Report. Vol. 1Environmental and Socioeconomic Characteristics (Revised Edition)

Nwangwu, N., Okechukwu, P., 1981. Environmental Pollution and its effect on soil. Petroleum Industry and Nigerian Environmental Proceedings of 1981. Int. Seminar (NNPC). 44-45.

Nwankwo, J.N., Irechukwu, D.O., 1981. Problems of environmental pollution Control in the Nigerian Petroleum industry. In: The petroleum industry and the Nigerian environment. Proceedings of 1981 International Seminar (NNPC), 102-107.

Nwankwo, J.N., Ifedi, C.N., 1988. Case studies in the environmental impact of oil production and marketing in Nigeria.. In: Sada, PO, Odemerho, FO (Eds).

Nyle, C., Brady, R., Neil, R., 2000. Soil texture, size distribution of soil particles and physical properties. In: The nature and properties of soil (12th edition) 119-128 . Prentice and Hall, Upper Saddle River New Jersey.

Odu, C.T.I., 1987. Degradation and weathering of crude oil under tropic conditions. The petroleum industry and Nigerian environment. Proceedings of 1987 International Seminar (NNPC). 16-20

Odum, P.D., 1994; Contamination of soils by petroleum hydrocarbons. Advances in Agronomy, 32, 197-216.

Okoko, K.A.B., Ibaba, I.S., 1999. Oil spillages and community disturbances: The SPDC and Niger Delta experience. J. Oil Politic. 2, 6-69.

Onojake, C.M., 2004. Petroleum hydrocarbons and associated metals of Ebocha 8 Oil spill polluted site in Niger Delta, Nigeria. M.Sc. Thesis. University of Port Harcourt, Nigeria Oudot II and KC Dupont KC, 1993; Soil and environment. An introduction. Oxford Press. London 256-280.

Overton, E.B.; Sharp, W.D.; Roberts, P. 1994; Toxicity of petroleum. In Basic Environmental Toxicology; Cockerham, L.G., Shane, B.S., Eds.; CRC Press:Boca Raton, FL, 133–156.

Sayles, G.D., Acheson, C.M., Kupferle, M.J., Shan, Y., Zhou, Q., Meier, J.R., Chang, L., Brenner, R.C., 1999. Land treatment of PAH-contaminated soil:performance measured by chemical and toxicity assays. Environ. Sci. Technol. 33, 4310–4317.

Sverdrup, L.E., Krogh, P.H., Nielsen, T., Kjær, C., Stenersen, J., 2003. Toxicity of eight polycyclic aromatic compounds to red clover (Trifolium pretense), rye grass (Lolium perenne), and mustard (Sinapsis alba). Chemosphere. 53, 993–1003.

Udosen, O.A., 1992. Indiscriminate disposal of effluents from industries. J. Environ. Quality. 48. 69-72.

Wade, R., 1990. The Exxon Valdez oil spill. The Environmental Health respons to manmade disasters. J. Environ. Health, 6, 34-40.

Wills, J., 2000. A survey of offshore oil field drilling wastes and disposal techniques to reduce the ecological impact of sea dumping. Sakhalin' Environ. Watch. 13, 23-29.