The control of Industrial emission via the subsoil green filters

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Abstract: The vast consumption of fossil fuel as an energy source for the various industrial, commercial and municipal activities, has led to the production of huge air pollutants, in a manner that needs more modern and effective efforts and technologies to prevent their hazardous consequences. This project aims to the use of the subsoil of nearby grounds as a natural filter to distribute these pollutants based on the soil’s high porosity and their ability to handle huge amounts of the gaseous effluents of the artificial projects. Soil properties such as the mechanical properties, porosity and ground water content were tested for different depths for two types of soils, in order to assess their readiness for the tentative use as a gaseous filter and to avoid the possible negative effects for the injection of gaseous pollutants on their biologic systems. An experimental system was made using a 5 KVA power generator, the gaseous emissions of which would be distributed through the subsoil via a buried pipe. The project also, included the precautions for the possible machine backpressure that may damage it. The wet clay type of soil has shown remarkable better performance than the dry sand type.

1. Introduction
The resulting wastes was always an issue for almost all types and all capacities of human being activities, that is due to their potential negative impacts on the receiving bodies for these wastes, whether these would be the atmosphere, surface waters, or lands. For centuries, it was a classical practice to use landfills as, to some extent, an easy and cheap management procedure for the industrial and municipal solid wastes. However, that was found the cause of additional pollution problems for the underground environment such as the farming areas, the ground-water wells and the possible seepage towards the rivers and lakes [1,2]. Many progresses and improvements were considered and applied to avoid these complications by numerous researchers who tested the practice of subsoil as filters to remedy the pollution loads on the environment due to the various types of domestic, commercial and industrial solid wastes, residues of radioactivity linked activities and the hazardous wastes. The land burial disposal of low/intermediate radioactivity level wastes, was the classical practice for many countries since the flourish on atomic/nuclear related industries, such as USA, UK, India, China, Canada, France, and the former Soviet Union as the primary choice for the protection their communities from the prospective risks of these wastes through the application of firm strategic, regulative and organizational actions that assure the safety of the recipient environment [3-5]. However, the airborne contaminants of the industrial or commercial emissions including the various transportation means, have been a big concern due to their vast ability to cover wide range of lands, as they were renowned of the content of large amounts of

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criteria pollutants, such as the hydrocarbons HC, and carbon monoxide CO, that may cause several health and economic adverse effects [6]. Researchers from various institutes studied the potentials of green means as safe handling mechanism against these gaseous releases to reach the allowable limits of exposure as were agreed by several relevant entities such as listed in table 1. Non edible tree leaves such as the Common myrtle tree were studied by AlMaliky, 2010 [7], and Kapoor, Bamniay and Kapoor, 2012 [8], and verified substantial control efficiency regarding the reduction of the concentration of the gaseous emissions from commercial and industrial sources to reach 73% and 82% of the emitted Nitrogen dioxide NO$_2$ and Carbon monoxide CO gases, respectively via the absorption process.

The main problem here is to test and prove the subsoil mediums capacity to filter the contaminates from the gaseous effluent streams of industrial sources, depending on the porous characteristic of these soils.

Table 1. Exposure Limits for Gaseous Pollutants according to the National Ambient Air Quality Standards NAAQS [9].

| Pollutant | Primary/ Secondary | Averaging Time | Level  | Form                                      |
|----------|--------------------|----------------|--------|-------------------------------------------|
| CO       | primary            | 8 hours        | 9 ppm  | Not to be exceeded more than once per year |
|          |                    | 1 hour         | 35 ppm |                                           |
| NO$_2$   | primary            | 1 hour         | 100 ppb| 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years |
|          | primary and secondary | 1 year      | 53 ppb (*) | Annual Mean                               |

(*) The level of the annual NO$_2$ standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

2. Laboratory arrangements

Two types of subsoils are selected to test their filtration potential of the gaseous contaminants released from a 5KW, Gasoline electrical power generator. These are dry sand soil and wet clay soil that are the most abundance in Baghdad, capital of Iraq. The external hosepipe of the power generator is elongated to allow the burial at various depths (20 cm-80 cm) underground each of these two soil types as demonstrated by figure 1, to test the effect of each burial depth in reducing the ground and aerial pollution index from each of the gaseous pollutants under study; CO, and NO$_2$, via a TG-501 gas analyzer above ground surface and at flat distances; 30cm, 60cm 90 cm and 120cm, from the end of the subsurface pipe end, after the laps of four hours of operation per day in an open area. As a protection measure for the hosepipe end, a wooden box is fixed above it to avoid and accidental soil avalanche that may clog it. ERGIL Storagetech™’s Model 193 Vacuum Relief, is utilized and connected to the pressure vessel and set to actuate at 1.3 psi that was measured as the backpressure limit, so as to elude the expected adverse effects on the power generator during the study period.
3. Results and Analysis

The first important issue that need to be assured is the porosity of the subsoil layers that would decide the ability of these regions to disseminate the gas streams of the hosepipe end, that is according to ASTM D7263-21[10]. Figure 2, demonstrate these values for both subsoil types and it tells that the wet clay type has higher porosities at all tested depths as compared to these of the dry sand soil, in an indication to higher distribution performance for the former soil type regarding the contaminated gas release. Also, it is determined that the porosity is relatively less at higher depths to these at shallow depths for both types of soils, as it goes to half its value at 80 cm depth as compared to that at 20 cm depth, and this might be attributed to the relative soil condensation at depths far from the surface. This leads to the conclusion that no significant enhancement would be expected with further burial depths for the hosepipe.

Figure 2. Variation of subsoil porosity with underground depth for the tested soils.

The statistical analysis of variance ANOVA-two way test for the results of the gas injections at variable underground depths confirmed very clear worth of depth and horizontal flat dimensions for the subsurface gas injection from the pollution release source as influences impacting the surface concentrations of the understudy gases with 95% confidence interval. This is demonstrated for the dry sand soil and the wet clay soil in table 2. That is also, clarified in the weak probabilities compared with the 0.05 significance zone, for all factors in the two types of subsoils, which might be attributed to the consequent gas concentrations
above the surface as a result for the injection through the subsurface layers. These thorough statistical analyses are tabulated in Table 2 for both subsoil types understudy.

**Table 2.** The ANOVA-two way statistical results for the two understudy subsoil types.

| Factors                  | CO     | NO₂    |
|--------------------------|--------|--------|
|                          | F-test | Probability | F-test | Probability |
| dry sand                 | 13.68  | 0.016  | 10.32  | 0.026  |
| wet clay                 | 8.89   |        | 18.93  | 0.009  |
| dry sand                 | 0.034  |        |        |        |
| wet clay                 |        |        | 0.026  |        |
| Subsurface depth         |        |        |        |        |

The performance of gas injection is best demonstrated by the gas concentrations; CO and NO₂ at the flat surface distances from the pollution source as a result of each injection depth. These records are demonstrated by figures 3 and 4 regarding the wet clay soil and figures 5 and 6 regarding the dry sand soil. In general, all these figures show significant reduction in the tested gas concentrations as the injection depth increases from zero (surface) to 60 cm. Where more than 73% of the initial CO gas concentration is dissipated through the surrounding wet clay subsoil, while it is about 52% in the dry sand soil. From the other side, it is reduced to about 75% and 62% respectively for the NO₂ gas. Beyond that, the reductions tend to be moderate to insignificant as the depths approach 80 cm, in an important sign that no further profitable gain might be expected with more injection depth, in addition to the risk of activating the backpressure valve or jeopardizing the machine (generator) as a result of possible clog. This might be attributed to the above mentioned lower porosities at these depths for both types of subsoils as a result of layers compactness. In an additional effect of the porosity on this injection remedy approach, it is clear from the mentioned results, that the wet clay of higher porosity all through the tested depths, proved better reduction performance for both tested gases. The records at flat distances for each tested depth, determine that the surface gas concentrations are highly affected by distancing away from the pollution source, as these records almost approach zero values at distances of 120 cm for both tested gases in both tested subsoils. However, the wet clay subsoil is determined to cause 8 times reduction as compared to the dry sand soil in handling the CO gas, and about 2.4 times regarding the NO₂.

**Figure 3.** The concentration of CO at flat distances vs. the injection depths—Wet clay.

**Figure 4.** The concentration of NO₂ at flat distances vs. the injection depths—Wet clay.
4. Conclusions
The dissipation of potential hazardous gas releases from the various industrial and commercial sources through the underground soils is studies and tested as one of the promising effective, green, and low cost solutions to produce more livable environment for the coming generations. This task is achieved in a laboratory sized approach to inject the gaseous emissions of a middle sized home power generator into various depths at two types of soils; wet clay and dry sand, that represent the most prevailing soil types in Baghdad, the capitol of Iraq. The injection depth and flat distance away from the pollution source is tested for both subsoil to determine their mutual impacts on the surface concentrations of the gases CO and NO$_2$. The gas stream subsoil injection proved a significant reduction performance for both soils against both gases understudy, as the final surface concentrations about 120 cm away from the pollution source approached the value of zero, although the wet clay subsoil is determined to be much significantly better filter media for CO and remarkable for the filtration of NO$_2$ as compared to the NO$_2$ gas. These remarks are highly reinforced by the statistical analysis ANOVA that showed high correlation between the vertical and horizontal injection dimensions.

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