*Pak. J. Bot.*, 51(4): 1231-1240, 2019. DOI: http://dx.doi.org/10.30848/PJB2019-4(39)

# RESPONSE OF DIFFERENT PLANT SPECIES TO POLLUTION EMITTED FROM OIL AND GAS PLANT WITH SPECIAL REFERENCE TO HEAVY METALS ACCUMULATION

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**Abstract**

It was hypothesized that different plant species vary in response to the oil and gas pollution in terms of composition and distribution pattern as well. Some of the plants have more tolerance to heavy metals accumulation in polluted ecosystem than others. Quantitative ecological techniques using quadrat methods were applied in a stratified random design around the Nashpa Oil and Gas Plant District Karak to check specific plant indicators that can grow, survive and show more tolerance against Oil and Gas pollution. In four directions from Gas Plant 10 stations were established at a distance of one Km from each other. Different size of quadrats i.e. 1×1 $m^{2,}$ 5×5 $m^2$ and 10×10 $m^2$ for herbs, shrubs and trees were used respectively. The phyto-sociological attributes of each species (density, relative density, frequency, relative frequency, cover, relative cover and Importance Values Index) were measured at each station. Furthermore, *Calotropis procera* was investigated for Pb, Cr and Cu heavy metals accumulation uisng atomic absorption spectrophotometer. All the collected data matrices were analyzed via Cluster analysis and Canonical Correspondence Analysis (CCA) using PC-ORD version 5 and CANOCO software. A total of 113 plant species were recorded belonging to 44 families from the Nashpa Oil and Gas Plant. Dominant and rare plants of heavy, moderate and less-polluted regions were identified and assessed. Result showed that *Calotropis procera* has more tolerant against pollution. It was concluded that the Oil & Gas Plant has significant effect on surrounding habitat plants for heavy metal accumulation. Higher concentration of K, pH and organic matter has significant effects ($p$≤0.002) on plant species diversity and its distribution pattern. Result of Pb and Cu accumulation in *C. procera* showed heavy metals accumulation increased from less polluted sites towards moderate and more polluted regions gradually. It is recommended that further study needed to examine other dominant species as well.

**Key words:** Heavy metal; Air pollution; *Calotropis procera*; Dominant plants; Spectrophotometer; CANOCO software.

**Abbreviation:** GHPL (Government Holding Private Limited), PPL (Pakistan Petroleum Limited), OGDCL (Oil and Gas Development Company Limited), BOPD (Barrels of Oil per day), MMSCFD (Million standard cubic feet per day), SNGPL (Sui northern Gas Pipeline Limited).

## Introduction

Natural oil and gas exploration activities have become major sources of environmental pollution in the 20[th] Century. In developing countries, due to rapid and unplanned industrialization the petroleum environmental pollution increases tremendously (Dincer 2000). Industrial pollution occurs due to numerous pollutants in the form of solid, liquids and gases. Varieties of toxic pollutants in the form of carbon monoxide (CO), volatile organic compounds (VOC), methane ($CH_4$), oxides of nitrogen (NOx), suspended particulate matter (SPM) and heavy metals in the environment due to such oil and gas Plants (Durrani *et al.,* 2004; Flagan & Seinfeld, 2012; Förstner & Wittmann, 2012; Bhandarkar, 2013). The presence of these pollutants causes an adverse effect on living organisms including both plant and animal that ultimately lead towards change in structure and function of an ecosystem (Bruno *et al.,* 2003; Walker *et al.,* 2012). Intensive disruptions at ecosystem and habitat level has threaten survival of many species especially those of a fragile nature (Guo *et al.,* 2017). Furthermore, plants near to oil and gas industries are the most exposed living beings which are being affected badly. Changes in their morphology, physiology and anatomy occur such in polluted ecosystem (Nazzal *et al.,* 2013; Nadgórska–Socha *et al.,* 2017).

In polluted ecosystem plants absorbed various contaminants including heavy metals (Paz-Alberto & Sigua, 2013; Khan *et al.,* 2017) that interrupt various physiological process of the plants. The different plant species act as sink to these pollutants and hence reduce its toxic effect in the surrounding polluted environment (Prajapati & Tripathi, 2008). Such pollution abatement functions are best performed by some of the pollutant tolerant plant species (Kuddus *et al.,* 2011). In other words, some of the plants have the ability to survive in such toxic sort of environment. The capacity of plants to take up heavy metals/contaminants is based on their special capabilities to accumulate and tolerate high level of toxic contaminants and heavy metals in shoot roots and other parts (Förstner & Wittmann, 2012). Therefore, such plants are the priceless gifts of nature that should be utilized wisely and preserved for future as well (D'Souza *et al.,* 2010). Leaves and exposed parts of plant act as persistent absorber, which provide large surface area for accumulation and absorption to air pollution (Joshi *et al.*, 2009). The plantation in such polluted industrial areas is site explicit activities of tolerance level of plants to oil and gas pollution (Das & Prasad, 2010; Sen *et al.,* 2017). Research work has been done to check the sensitivity of plant species based on selected parameter i.e., ascorbic acid content, relative water content, chlorophyll content and leaf extract pH but little attention was given to phytoremediation (Rajput & Agrawal 2005; Chauhan & Joshi 2008). To identify the top pollutant indicator species multivariate statistical techniques help to summarize the vegetation in large complex data sets and generate hypothesis about the structure and variation in plant species composition and pattern in relation to environmental factors (Anderson *et al.*, 2006; Iqbal *et al.*, 2017).

Nashpa Oil and Gas Plant is one of the major oil and gas producing plant in Pakistan that causes widespread environmental pollution. It was hypothesized that different plant species show different responses to the oil and gas pollution and hence their species composition, distribution pattern and abundance vary along environmental gradients. The dominant plant species may have more tolerance in heavy metal accumulation than others. Moreover, such effects had never been investigated before on vegetation as a whole. Therefore, the present study was conducted to evaluate the influence of Nashpa oil and gas plant pollution on aspects of vegetation both at species and assembly level. The study will further be of technical help to air pollution management authorities through corrective measurements.

## Materials and Methodology

**Study area:** The Nashpa Oil and Gas Plant covers an area of 500 kanals, located at 32° 48' to 33° 23' North latitudes, 70° 40' to 71° 30' East longitudes, having an area of 3372 sq. Km with Semi-arid climate in the District Karak, Pakistan. It shares border with Lakki Marwat on its South, Minawali at South East, Bannu District at South West, Kohat at North Waziristan Agency at West side (Tabassum, 2012). This Plant was the joint adventure of three companies including Government Holding Private Limited, Pakistan Petroleum Limited and Oil and Gas Development Company limited with mutual share of 15, 28.55 and 56.45% respectively. Oil and Gas production was started in May 2010 and presently from six wells i.e. Nashpa-1, Nashpa-2, Nashpa-3, Nashpa-4, Nashpa-X5 and Nashpa-7 oil and gas are extracting. The production of the Plant is 25270 Barrels of oil per day and storage capacity is 120000 Bbls. Gas production is 90.3860 Million standard cubic feet per day and is sold to Sui northern Gas Pipeline limited is 89.4860 Million standard cubic feet per day (Oil and Gas Development Company limited Nashpa Oil and Gas field Karak, KPK).

**Vegetation sampling:** Quadrat quantitative ecological techniques were used to measure the effect of air pollution and other environmental variables on plant species composition, abundance and distribution pattern. Nashpa Gas Plant was taken as central point and quadrats were laid in all four directions i.e., North, South, East and West up to a distance of 10 Km. At each direction from central point 10 stations were established at one Km interval up to the distance of 10 Km (A total of 120 quadrats). The size of quadrats were kept 1×1 $m^{2,}$ 5×5 $m^2$ and 10×10 $m^2$ for herbs, shrubs and trees respectively (Ahmad *et al.*, 2016; Khan *et al.*, 2013; Khan *et al.*, 2016a). The phyto-sociological attributes i.e., Frequency (F), Density (D), Cover (C), Relative Frequency (RF), Relative Cover (RC). Relative Density (RD) and Importance Value Index (IVI) were calculated at station level. The plant specimens were collected, labeled with tags, placed in blotting papers and pressed using plant presser. Mercuric Chloride and Ethyl Alcohol solution were used to poison the plant specimens. Specimens were then mounted on standard herbarium sheets having size of 17.5 × 11.5 inches. All the plant specimens were identified using the Flora of Pakistan and other available literature (Nasir & Ali, 1972; Ali & Qaiser, 2004). The Voucher plant specimens were deposited in the Herbarium of Quaid-i-Azam University, Islamabad, Pakistan.

**Soil collection:** The soil samples at a depth of 30 cm were collected from each quadrat by using soil sampling instrument. The collected samples were put in polythene bags, dried at room temperature and sieved for further analysis. The physiochemical analyses of soil i.e., pH, Electrical Conductivity (E.C), Soil Texture (ST), Organic Matter (OM), Magnesium (Mg), Calcium (Ca), Potassium (K) and Phosphorus (P) concentrations were analyzed in the Agriculture Research Department-Rawalpindi, Government of the Punjab. In addition to, root samples were also collected and preserved in order to check the ability of selected dominant plant species for heavy metal accumulation.

**Heavy metal analysis:** The acid digestion method was used for samples preparation of Atomic absorption according to protocol given by (Zasoski & Burau, 1977; Filgueiras *et al.*, 2000). One gm of oven dried C*alotropis procera* root and soil were taken and grounded with help of pestle and mortar. Ten ml of Nitric acid and Perchloric acid in 3:1 were added in 50 ml conical flask and kept for 24 hours. For initial digestion, sample was placed in fume hood and a temperature up to 150˚C was given for one hour. The temperature was raised up to 235˚C till white fumes appear. After cooling mixture was filtered, 40 ml of distilled water was added. At last the sample was analyzed through atomic absorption spectrophotometer for heavy metals accumulation.

**Data preparation and analysis for PC-ORD and CANOCO software's:** All the collected plant species data and environmental variables data were arranged in MS EXCEL sheet for multivariate statistical analyses. Species area Curves were constructed using PCORD version 5 (Lepš & Šmilauer, 2003). Whereas the environmental data and species data matrices based on IVI of plants were analyzed through CANOCO software version 4.5 to evaluate the effect of Nashpa Gas Plant pollution and measured environmental variables on the plant species composition, distribution pattern and abundance along with pollution gradient.

## Results

Preliminary a total of 113 plant species were recorded from 120 quadrats belonging to 44 families and 96 genera around Naspha Oil and Gas Plant. It contains 76 (67.26%) herbs, 21 (18.59%) shrubs and 16 (14.16%) tree species. The family Poaceae was the topmost dominant family having 17 plant species covering up 15% of the total plant species in the region followed by Solanaceae with 8 plant species. The remaining plant families have less than 8 species and encompass about 77% of the total plants in the studied region (Fig. 1).

**Species area curve (SAC):** The first test performed was Species Area Curve (SAC) via PC-ORD version 5. It was drawn to know whether sample size was adequate or not that clarify the species composition in relation to sample size. It showed that the maximum number of plant species appearing up to station number 25 and the species curves become parallel after station No. 25 and no more species were recorded. It proved that the adequate sampling in the targeted region (Fig. 2).

**Cluster analysis:** Cluster Analysis classifies all the plant species and environmental variables into 3 habitat types or associations. These associations could be generalized as heavily polluted, moderately polluted and less polluted habitat.

**Distribution pattern:** Regarding distribution, minimum numbers of plant species were recorded in the polluted (closest) habitat type or zones around Nashpa Oil and Gas Plant as compared to the stations situated at moderate and less polluted sites. As we went away from the polluted region considerable increase in number of species was observed. A total of 288 individual plants were reported in heavily polluted habit termed as “S-1” (2 Km away from Gas Plant). In moderate polluted region S-2 (2-6 Km away from thye Gas Plant) 957 individual plants were recorded. While in less polluted region S-3 (6-10 Km away from the Gas plant) 1524 individuals were recorded in the same sample size.

**Frequent and less frequent plant species of heavily polluted region of the Nashpa Gas Plant:** The most frequent tree species of heavily polluted region included *Prosopis juliflora, Capparis decidua* and *Ziziphus nummularia* with maximum number of plant species. In shrub layer *Calotropis procera, Withania coagulans,* and *Rhazya stricta* were dominant plants. While *Poa annua, Parthenium hysterophorus* and *Dichanthium annulatum* were dominant herbs of the heavily polluted regions. At the same time, *Ziziphus spina-christi, Eucalyptus camaldulensis* and *Monotheca buxifolia* trees were rarely observed. The *Periploca aphylla, Otostegia limbata* and *Withania somnifera* were the rare shrubs. While *Eragrostis minor, Peganum harmala* and *Xanthium spinosum* were rare herbs of heavily polluted regions as compared to moderate and less polluted regions of the study area.

**Frequent and less frequent plants of the moderate polluted regions:** The most frequent tree species of Moderate-polluted regions included *Acacia modesta, Ziziphus jujuba* and *Monotheca buxifolia.* Dominant shrubs revealed *Justicia adhatoda, Calotropis procera* and *Otostegia limbata.* While, dominant herbs included *Cynodon dactylon, Tragus roxburghii* and *Parthenium hysterophorus.* The top rare tree, shrub and herbs comprised of *Eucalyptus camaldulensis, Melia azedarach, Salvadora oleoides, Haloxylon griffithii, Lantana indica, Sageretia thea, Aristida adscensionis, Cymbopogon citratus* and *Cyperus laevigatus* respectively with minimum number of plant species.

**Frequent and less frequent plant species of less-polluted regions of the study area:** The most frequent tree species of less-polluted regions included *Monotheca buxifolia, Acacia nilotica* and *Dalbergia sissoo.* In shrub layer, frequent plants were *Withania somnifera, Dodonaea viscosa* and *Parkinsonia aculeata.* While, *Euphorbia prostrata, Brachiaria reptans* and *Conyza canadensis* were the most frequent herbs species. At the same time less frequent tree, shrub and herb species included *Salvadora oleoides, Tamarix aphylla, Ziziphus sativa, Haloxylon griffithii, Lantana indica, Solanum incanum, Digera muricata, Phyla nodiflora* and *Cyperus laevigatus* with minimum number in the region.

**Heavy metal accumulation in *Calotropis procera* a dominant shrub of tolerant nature:** Among any other observed tolerant species, one was *Calotropis procera*, that was further investigated for heavy metals. Results showed that the concentration of heavy metals accumulation in this plant increased gradually from less polluted sites towards moderate and more polluted regions. The concentration of lead (Pb) was found lower i.e., 0.04 mg/kg a sample collected from less polluted region, 0.11 mg/kg at moderate region and 0.15 mg/kg at heavily polluted regions of the study area. The low accumulation (0.006 mg/kg) concentration of Chromium (Cr) was measured in less polluted sample followed by moderated (0.03 mg/kg) and polluted (0.01 mg/kg) regions respectively. Regarding copper (Cu) accumulation high amount of 0.1 mg/kg was found in the polluted region plant sample followed by moderate 0.04 mg/kg and 0.002 mg/kg in less polluted regions. The rate of heavy metal accumulation was significantly increased as we moved from less polluted area towards moderate and more polluted regions of the study area (Table 1 & Fig. 3).

**Environmental variables:** All the species data and environmental data matrices of the study area were put and analyzed through CANOCO Software version 4.5 to analyze and understand the impact of environmental variables with special reference to Oil and Gas Plant pollution. It was resulted that oil and gas plant with other co-variables i.e., organic matter, texture class, saturation, pH, electrical Conductivity, potassium (K), phosphorus (P), distance (D), magnesium (Mg) and calcium (Ca) have significant effect ($p \leq 0.05$) on plant species composition, distribution pattern and abundance (Tables 2 and 3).

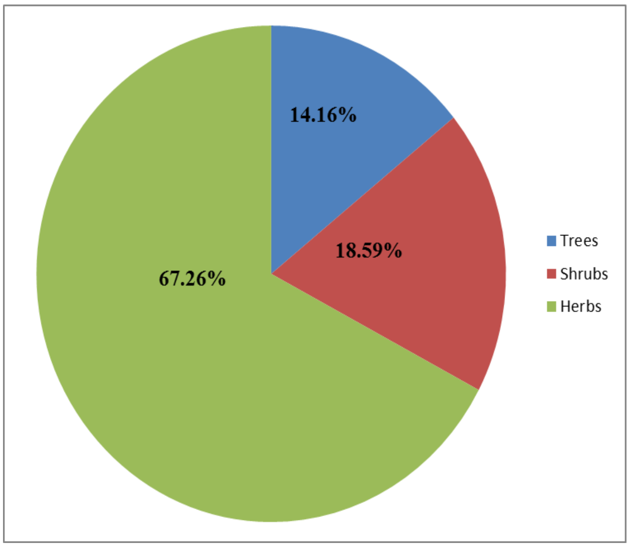


Fig. 1. Distribution of trees, shrubs and herbs in percentage.

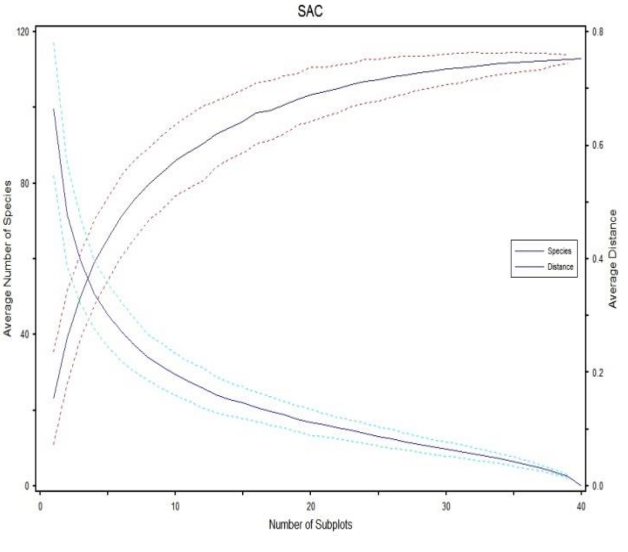


Fig. 2. The species area curves (SAC) of 113 plant species distributed among 40 stations.

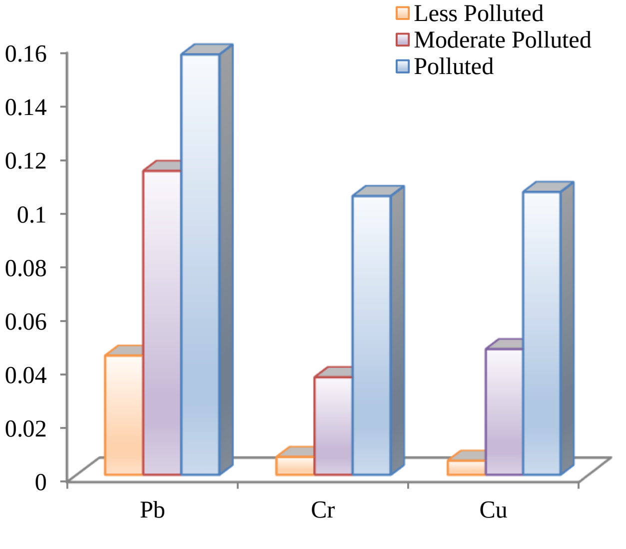


Fig. 3. Comparison of heavy metal contents of *Calotropis procera* in polluted, moderate and less polluted localities.

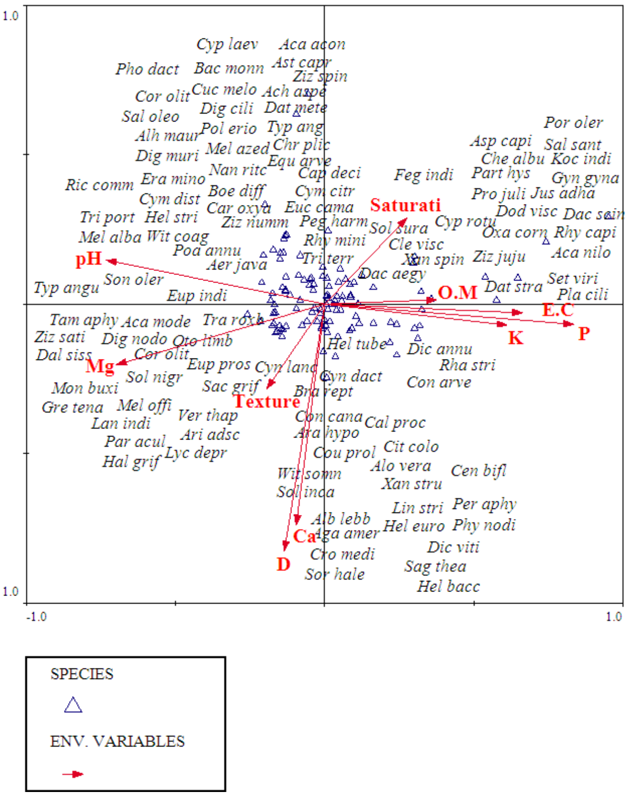


Fig. 4. Ordination of plant species under the influence of various environmental variables of the study area.
Satu= Saturation, O.M= Organic matter, E.C= Electrical Conductivity, P= Phosphorus, K= Potassium, Ca= Calcium, D= Distance, Textu= Texture, Mg= Magnesium.

The ordination of plant species through CCA bi-plot (Fig. 4) showed differential and similarity indexes in plant species and the distance between them (each triangle represented a plant species). The first quadrant of CCA bi-plot of species indicated that approximately 25.6% of the total plant species were clustered around saturated soil condition at relatively lower organic matter concentration. While in 2$^{nd}$ quadrants 31.8% of the entire plants were assembled under higher pH. Both these quadrants revealed maximum polluted ailment. In 3$^{rd}$ quadrants 20.3% of the plant species were assembled under the influence of environmental variables i.e., higher concentration of Magnesium (Mg), high texture class, more distance and higher Ca percentage with less pollution. Similarly, the 4$^{th}$ quadrants illustrated from higher concentration of EC and more Phosphorous to higher Potassium 22.1 % plant species of the total study area with moderate pollution (Fig. 4).

On the other hand, if we compare polluted, moderate and less polluted regions in light of physiochemical properties of soil through CCA bi-plot, the more polluted regions have higher pH along saturated soil condition (represented by blue up-triangle in Fig. 5). While the moderate sites assemble at higher concentration of organic matter, higher electrical conductivity, high concentration of phosphorous, higher potassium and calcium (represented by pink diamond in Fig. 5). Whereas, the less polluted regions have higher concentration of magnesium and texture class environmental variables (represented by green circle in Fig. 4).

**Table 1. Heavy metal concentration in *Calotropis procera* collected from various localities of the study area.**

| Plant samples | Pb | Cr | Cu |
|---|---|---|---|
| Less polluted | 0.044583 | 0.006675 | 0.00525 |
| Moderate polluted | 0.113333 | 0.0365 | 0.047 |
| Polluted | 0.156667 | 0.104 | 0.1055 |

L.P= Less polluted, M.P= Moderate polluted, P= Polluted

**Table 2. Canonical corresponding analysis summery of all plant species with all environmental variables.**

| Axis | 1 | 2 | 3 | 4 | Total inertia (IT) |
|---|---|---|---|---|---|
| Eigen values (EV) | 0.249 | 0.159 | 0.127 | 0.119 | 3.659 |
| Species-environmental correlations (SEC) | 0.957 | 0.816 | 0.841 | 0.705 | |
| Cumulative percentage variance of species data (CPVSP) | 6.8 | 11.1 | 14.6 | 17.9 | |
| Species-environment relation (SER) | 23.4 | 38.4 | 50.4 | 61.7 | |

SMC Test

| Test of significance of first canonical axis TSFCA | | Test of significance of all canonical axes TSACA | |
|---|---|---|---|
| Eigen values (EV) | 0.249 | Trace | 1.060 |
| F-ratio (FR) | 2.113 | F-ratio (FR) | 1.183 |
| P-value (PV) | 0.0580 | P-value (PV) | 0.0420 |

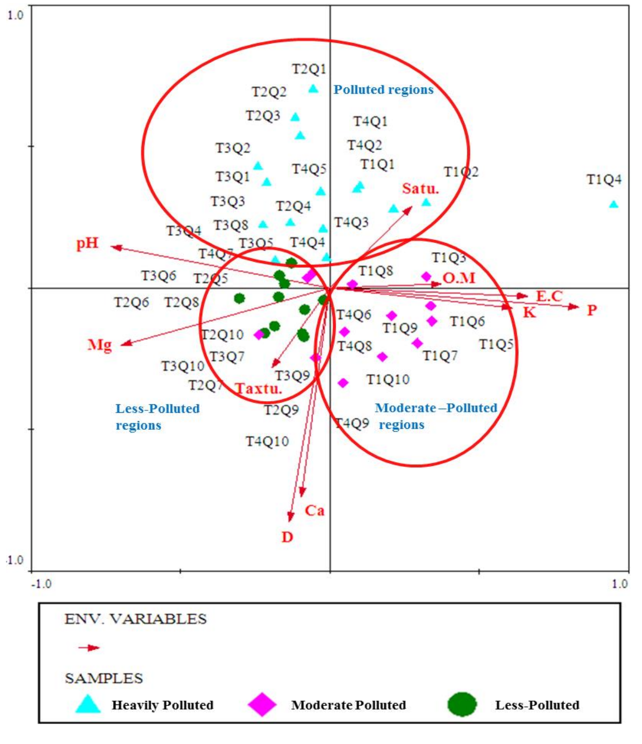


Fig. 5. Ordination of various stations in relation to different environmental variables.
Satu= Saturation, O.M= Organic matter, E.C= Electrical Conductivity, P= Phosphorus, K= Potassium, Ca= Calcium, D= Distance, Textu= Texture, Mg= Magnesium

## Discussion

The oil and natural gas industries being the biggest sector in term of economics values are also the global power houses which provide over half of the world with energy. The amount of consumption of oil and gas is 30 billion barrels per day. According to an estimate energy demand will further increase up to 118 million barrels per day. Due to increase in consumption of oil and gas by 2030 air pollution will also increase and hence creating disturbance of natural ecosystems its functions and potential services. This article evaluated the influence of oil and gas pollution on plant species composition, distribution pattern and its associated dominant and rare species with reference to heavy metals accumulation. Plant species directly depend on environmental conditions for growth, development and survival. In current study, the vegetation of heavily polluted regions was dominated by *Prosopis juliflora*, *Capparis decidua*, *Ziziphus nummularia*, *Calotropis procera*, *Withania coagulans*, *Rhazya stricta*, *Poa annua*, *Parthenium hysterophorus* and *Dichanthium annulatum* which were found in region of higher concentration of Mg, Ca, lower organic matter and texture class environmental variables. Kabir *et al.*, (2010) also reported some of these species prominent around the cement industries in Karachi Pakistan, where higher concentration of Calcium carbonate and low amount of organic matter were determinant variables. Soil around these industries was mostly porous with tendency of higher water holding capacity. Number of researcher also reported that the polluted region have more amounts of sulphur and chloride contents which usually cause adverse effects the growth and development in these regions (Weggler *et al.*, 2004). Some of the co-dominant species of the polluted region were *Phoenix dactylifera*, *Albezia lebbeck* and *Dilbergia sisso*. Al-Khashman *et al.*, (2011) also reported *Phoenix dactylifera* as a species to bio-monitor pollution. According to Singh *et al.*, (2002), *Dilbergia sisso* is the indicator of lead pollution. Our findings showed similarities with Das & Prasad (2010) who studied the effect of air pollution of industrial area and found *Albezia lebbeck* as one of the sensitive species to air pollution. Among the shrub *Calotropis procera*, *Withania coagulans* and *Rhazya stricta* were dominant in the heavily-polluted parts around the Gas plant as compared to parts away from it. A study conducted on the effects of heavy metals contamination on *Withania somnifera* in polluted and control conditions revealed variation of *Withania somnifera* abundance (Saidulu *et al.,* 2013). Our present study also revealed ability of *Calotropis procera* for heavy metal accumulation. Its ability of accumulation significantly increases from less polluted regions towards moderate and heavily polluted stations. Studies on the effect of heavy metals on *Calotropis procera* in 4 different sites showed that higher concentration of heavy metals had significant effect on plant species in term of abundance and distribution (D'Souza *et al.,* 2010). In addition, *Parthenium hysterophorus* was more frequent in polluted sites of Nashpa Gas plant. Similar studies conducted on *Parthenium hysterophorus* in polluted regions showed harmony with our results (Dwivedi & Tripathi, 2007). Some of the species like the *Ricinus communis* was present both in polluted and non-polluted region. This finding was also quite similar to the findings of (Dwivedi & Tripathi, 2007) work. The *Cyprus rotundus* and *Achyranthus aspera* were present in the polluted regions while *Cyanodon dactylon* and *Xanthium strumanium* were abundantly present in less-polluted regions compared to polluted regions.

Finding of this research showed that the *Acacia nilotica* was one of the dominant trees of comparatively less-polluted region. Other influencing variables were higher concentration of Ca and Mg in these less polluted stations. Some other studies reported *Acacia arabica, Tamarindus indica* and *Dalbergia sisoo* had low dust accumulation on plant surface because of long petiole and smooth surfaced of the leaves (Thakar & Mishra, 2010). *Cynodon dactylon* was one of the most abundant species of the region and can tolerate to drought and polluted condition due to the warm and dry climatic conditions of the study area. *Solanum surattene, Carthamus oxyacantha, Acacia modesta* and *Calotropis procera* abundantly grow in drier station of the study area. Chaudhry *et al.,* (2001) also recorded *Acacia modesta* as a dominant plant of the dry climate. In addition to, *Rhyzia stricta* and *Peganum harmala* were mostly present in the polluted parts. A study conducted by Shah *et al.,* (2013) on the harmful effects of heavy metal on *Rhyzia stricta* and *Peganum harmala* showed a concentration in sequence of Fe> Zn> Mn> Cu> Ni> Cr> Cd> Pb. Though the heavy metals have a vital role and importance in biogeochemical cycles but are toxic and harmful above a concentration exceeded than a normal standard (Khan *et al.,* 2017). In present project, the *Zizypus jujuba* was present both in polluted and less-polluted regions indicating the pollution had no significant effect on it. Finding agreed with our results were also reported by checking the influence of air pollution on *Zizypus jujube* in industrial area where the impact was not quite on this plant (Lakshmi *et al.,* 2009). The phyto-sociological attribute helps in understanding the vegetation composition and species distribution pattern of an area. Industrial wastes lead towards negative impacts on plant species habitats and over all ecosystems. One of the important applications of present research was the use of multivariate statistical techniques to elaborate the impact of heavy and pollution on abundance of plants. Plant species distribution pattern and composition changes along various environmental factors in a gradual manner as a function of continuity in environmental gradient. Three major habitat types of the study area, were demarcated which could be compared with other studies where same techniques were used (Khan *et al.,* 2016a; Khan *et al.,* 2016b; Pruchniewicz, 2017). These studies assessed the influence of various environmental variables on plant species distribution and composition. To measure the effect of heavy metals and pollution on abundance and distribution of plants use of CANOCO Software could be compared with studies conducted by (Khan *et al.,* 2012; Khan *et al.,* 2013; Khan *et al.,* 2016b; Bano *et al.,* 2018) where they assessed the impact of topographic and edaphic factors on plant composition and distribution pattern.

## Conclusion

It was concluded that the Nashpa Oil and Gas plant has significant effect on plant species distribution pattern, composition and abundance. Minimum numbers of individual plants were recorded in heavily polluted region as compared to moderate-polluted and less-polluted regions. Heavily-polluted region contain higher pH and saturated soil condition, dominated by *Prosopisjuliflora, Capparis decidua, Ziziphus nummularia, Calotropis procera, Withania coagulans, Rhazya stricta, Poa annua, Parthenium hysterophorus* and *Dichanthium annulatum* plant species. The most abundant plant species of moderate polluted regions included *Acacia modesta, Ziziphus jujuba, Monotheca buxifolia, Justiciaa dhatoda, Otostegia limbata, Cynodon dactylon* and *Tragus roxburghii* with phosphorus, EC, organic matter and Potassium edaphic variables. While the less-polluted regions showed higher concentration of Mg, Ca and texture class environmental variables dominated by plant species like *Acacia nilotica, Dalbergia sissoo, Dodonaea viscosa, Parkinsonia aculeata, Euphorbia prostrata, Brachiaria reptans* and *Conyza canadensis*. Heavy metal accumulation by *Calotropis procera* increases gradually from less polluted sites towards moderately and heavily-polluted regions. Introduction of such species will result to clean oil and gas pollution in order to sustain the natural environment. Further studies can be help to investigate is needed to investigate the tolerance level of heavy metal accumulation in these dominant plants and application of indicator species in search for underground natural gas and oil fields.

## Acknowledgment

The authors would like to extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for its funding this Research group NO. (RG-1435-014).

**Table 3. Influence of various environmental variables and its indicator values of different plant species of the study area.**

| S.No. | Botanical names | Max grp | IV | p * |
|---|---|---|---|---|
| | **Calcium** | | | |
| 1. | *Dodonaea viscosa* | 70 | 45.9 | 0.0578 |
| 2. | *Rhazya stricta* | 70 | 27.5 | 0.0458 |
| 3. | *Citrullus colocynthis* | 70 | 69.3 | 0.005 |
| 4. | *Cousinia prolifera* | 70 | 41.5 | 0.0228 |
| 5. | *Digitaria nodosa* | 52 | 54.9 | 0.052 |
| 6. | *Melilotus alba* | 52 | 66.7 | 0.024 |
| | **Distance environmental variable** | | | |
| 1. | *Monotheca buxifolia* | 9 | 29.4 | 0.0406 |
| 2. | *Brachiaria reptans* | 5 | 36.6 | 0.0184 |
| 3. | *Cousinia prolifera* | 10 | 27.3 | 0.0524 |
| 4. | *Cynodon dactylon* | 7 | 18.9 | 0.0572 |
| 5. | *Cyperus rotundus* | 4 | 37.5 | 0.0088 |
| | **Electrical conductivity** | | | |
| 1. | *Acacia modesta* | 11 | 48 | 0.0352 |
| 2. | *Periploca aphylla* | 11 | 56.5 | 0.0466 |
| 3. | *Aerva javanica* | 11 | 52.2 | 0.0592 |
| 4. | *Cousinia prolifera* | 11 | 58.5 | 0.0434 |
| 5. | *Dactyloctenium aegyptium* | 11 | 82.8 | 0.0072 |
| 6. | *Gynandropsis gynandra* | 11 | 50 | 0.0544 |
| 7. | *Heliotropium europaeum* | 11 | 78.7 | 0.008 |
| 8. | *Plantago ciliata* | 11 | 50 | 0.053 |
| | **Potassium** | | | |
| 1. | *Monotheca buxifolia* | 289 | 29.5 | 0.0438 |
| 2. | *Withania coagulans* | 289 | 20.5 | 0.0208 |
| 3. | *Datura metel* | 146 | 57.1 | 0.0348 |
| 4. | *Solanum nigrum* | 134 | 60 | 0.0122 |
| | **Magnesium** | | | |
| 1. | *Ziziphus nummularia* | 7 | 36.1 | 0.038 |
| 2. | *Asparagus capitatus* | 2 | 56.8 | 0.0066 |
| 3. | *Dodonaea viscosa* | 7 | 45.4 | 0.0174 |
| 4. | *Parkinsonia aculeata* | 7 | 45.6 | 0.0248 |
| 5. | *Aristida adscensionis* | 6 | 42.9 | 0.0226 |
| 6. | *Chenopodium album* | 2 | 33.8 | 0.0494 |
| 7. | *Cynodon dactylon* | 6 | 29.2 | 0.0518 |
| 8. | *Datura metel* | 7 | 46.9 | 0.013 |
| 9. | *Datura stramonium* | 3 | 32.7 | 0.0724 |
| 10. | *Gynandropsis gynandra* | 3 | 40 | 0.038 |
| 11. | *Solanum nigrum* | 7 | 40.8 | 0.0296 |
| 12. | *Sonchus oleraceus* | 7 | 40.6 | 0.04 |

**Table 3. (Cont.d.).**

| S.No. | Botanical names | Max grp | IV | p * |
|---|---|---|---|---|
| | **Organic matter** | | | |
| 1. | *Ziziphus nummularia* | 36 | 39.5 | 0.008 |
| 2. | *Agave Americana* | 62 | 50 | 0.0258 |
| 3. | *Cousinia prolifera* | 78 | 39.7 | 0.0444 |
| 4. | *Equisetum arvense* | 26 | 35.1 | 0.0598 |
| 5. | *Peganum harmala* | 78 | 45 | 0.0508 |
| 6. | *Phyla nodiflora* | 78 | 83.3 | 0.0052 |
| 7. | *Tribulus terrestris* | 62 | 39.8 | 0.033 |
| | **Phosphorous** | | | |
| 1. | *Acacia modesta* | 11 | 42.9 | 0.0152 |
| 2. | *Astragalus caprinus* | 4 | 47.8 | 0.099 |
| 3. | *Dactyloctenium aegyptium* | 11 | 64.7 | 0.029 |
| 4. | *Heliotropium europaeum* | 11 | 50 | 0.0438 |
| 5. | *Linum striatum* | 8 | 63.6 | 0.0224 |
| | **pH** | | | |
| 1. | *Asparagus capitatus* | 6 | 60.2 | 0.0194 |
| 2. | *Dactyloctenium scindicum* | 6 | 64.1 | 0.0108 |
| 3. | *Datura stramonium* | 6 | 63.2 | 0.012 |
| 4. | *Dicarum viticeta* | 6 | 62.8 | 0.0102 |
| 5. | *Gynandropsis gynandra* | 6 | 66.7 | 0.0048 |
| 6. | *Kochia indica* | 6 | 66.7 | 0.0038 |
| | **Saturation** | | | |
| 1. | *Melia azedarach* | 30 | 12.5 | 0.4745 |
| 2. | *Monotheca buxifolia* | 29 | 53.2 | 0.0066 |
| 3. | *Grewia tenax* | 29 | 61.5 | 0.001 |
| 4. | *Otostegia limbata* | 29 | 33.5 | 0.0496 |
| 5. | *Conyza Canadensis* | 29 | 41.8 | 0.0286 |
| 6. | *Datura metel* | 32 | 34 | 0.0364 |
| 7. | *Digitaria nodosa* | 29 | 42.9 | 0.011 |
| 8. | *Eragrostis minor* | 32 | 26 | 0.0586 |
| | **Texture class** | | | |
| 1. | *Capparis decidua* | 2 | 58.3 | 0.0344 |
| 2. | *Monotheca buxifolia* | 2 | 76.4 | 0.0086 |
| 3. | *Grewia tenax* | 2 | 68.5 | 0.003 |
| 4. | *Otostegia limbata* | 2 | 41.5 | 0.0378 |
| 5. | *Conyza Canadensis* | 2 | 60.4 | 0.0142 |
| 6. | *Digitaria nodosa* | 2 | 46.6 | 0.022 |
| 7. | *Solanum nigrum* | 2 | 41.7 | 0.0362 |

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(Received for publication 24 April 2018)