

Phytochemical and physicochemical characteristics of Vetiver plant (*chrysopogon zizanioides*) in different climatic regions of Iran

sahel Haghighi

sahel.haghighi66@gmail.com

Soil Conservation and Watershed Management Research Institute <https://orcid.org/0009-0009-5900-3904>

Forood Sharifi

Soil Conservation and Watershed Management Research Institute <https://orcid.org/0000-0003-2817-3416>

Mohammad Azadbakht

Mazandaran University of Medical Sciences <https://orcid.org/0000-0002-2451-4968>

Research Article

Keywords: Khusimol, Tehran, Gilan, Golestan

Posted Date: August 19th, 2025

DOI: <https://doi.org/10.21203/rs.3.rs-7379490/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.
[Read Full License](#)

Additional Declarations: The authors declare no competing interests.

Abstract

Background

Vetiver plant An important and fragrant plant genus that belongs to the Gramine cereal family and sub-family Gorgiae and consists of ten species. The variety family belongs to the genus Parasorghum and Chrysopogon. Its chemical composition has a Sesquiterpene structure. Also, its treatment for some diseases such as control and treatment, antibiotic properties, treatment of malaria has been proven.

Objectives

The present study was conducted with the aim of investigating the phytochemical and physicochemical properties and anti-inflammatory activities of the species vetiver plant (chrysopogon zizanioides) in three regions with different climates.

Methods

Vetiver plant roots in three regions with different climates in each region, three levels with different slopes in Gilan province, first level (30-40 degrees), second level (40-50 degrees), third level (60-70 degrees) and in Tehran province, first level (40-50 degrees), level second (70-80 degrees), third level (80-90 degrees) and in Golestan province first level (60-70 degrees), second level (70-80 degrees), third level (80-90 degrees) randomly in each The surface of four root samples of vetiver plant was sampled. Khusimol, total phenol, total flavonoid content were determined using acidic potassium. Dichromate, Folin-Siocaltio and Aluminum Chloride methods, respectively. Gas chromatography (GC-MASS) method was also used for identification. In addition to the small amount of Khusimol, the physicochemical properties of the Vetiver plant (chrysopogon zizanioides) and thiurase including macroscopic and organoleptic properties, solubility, foreign matter and ash values were evaluated.

Results

The highest levels of Khusimol, phenolic compounds and flavonoids were observed in vetiver plant roots in the side slope of Narmab dam reservoir located in Golestan province.

The physicochemical properties of vetiver plant roots in the Narmab-Golestan reservoir range compared to the Hemet-Tehran highway range and the side slopes of the Sangar dam reservoir have a suitable standard.

Conclusions

This study showed that the amount of chosymol, total phenolic and total flavonoids of vetiver plant roots in steep slopes changes with the change of soil slope. In fact, with the increase of the soil slope and the height above sea level in all three regions, the slopes of the Hemmat-Tehran highway (semi-arid climate), the side slopes of the Narmab-Golestan dam reservoir (mountainous and humid climate), the side slopes

of the Sangar dam reservoir - Gilan (moderate and humid climate) the amount of Khusimol, total phenolic and total flavonoid has increased.

1. Background

Due to the variety of climate, soil, geographical location and altitude, the country of Iran has a high biological diversity, as a result, it is one of the best regions for the growth of medicinal plants (Raeisi Monfared et al., 2022). Knowing the ecological power and the correct methods of exploitation is one of the important and necessary cases of exploitation of medicinal plants in the natural areas of the country. Considering the economic importance of medicinal plants, the users, knowing their economic value and in line with sustainable income, will be an effective and powerful factor for their protection and restoration, and will indirectly protect the fields of natural resources and their genetic reserves (Jahantighi et al., 2019). Due to the climatic changes, the appearance and medicinal substances of medicinal plants in terms of quantity and quality as well They undergo changes. Therefore, considering the very good potential of the country in the field of various essential and medicinal plants, by knowing plant species and obtaining the necessary information about their growing places and ecological characteristics, optimal scientific planning should be carried out in the use of compounds and Natural products with plant origin and promotion of the basic methods of exploitation of these plants (Yavari et al., 2010). Since long ago, vetiver was cultivated to protect the soil against erosion, and now it is used to protect the uncovered canals, the side walls along the waterways, around the foothills, and the embankments around the rice paddies. By growing vetiver plant in the way of water entering the dams, it traps a lot of mud. Vetiver is an important and aromatic plant genus that belongs to the family of gramineae and sub-family of gourds and consists of ten species. The variety family belongs to the genus *Parasorghum* and *Chrysopogon*. The presence of Vetiver plant (*Chrysopogon zizanioides*) and *Luconi* from the Indian subcontinent and *V. nigriflora* in Africa has been reported. It is distributed in tropical regions. In the past, people used the dried roots of the vetiver plant to treat toothache. After some time, due to migration of nomads and pasture grazing, the presence of vetiver essential oil in the pastures decreased. Vetiver is known as "magic herb". In Thailand, people called it "miracle grass". In many people it was known by the common name of *Wor*. Common herbal medicines were used in local communities and indigenous medical knowledge. The medicinal value of vetiver was developed in the 18th century. At that time, there was a time when vetiver's roots and leaves dry up due to frequent use. These attributes of vetiver grass are used in the fields of water and soil protection, erosion control, soil stabilization, animal feed and medicine. Almost all humans experience one or more health problems, and suffer from illness, at some point in time. And it is used to provide prescribed treatments. Many developing people use vetiver to treat diseases. The roots of *v. zizanioides* are able to treat some common and dangerous diseases. It can be used to treat malaria, treat dental problems, etc. Vetiver roots cultivated by spraying the growing period of 6 to 12 months from the beginning of planting, it is possible to harvest and use medicinally from its substance. These freshly harvested roots are washed completely in the first step and then placed in a controlled temperature of 24°C to 36°C for 2 or 3 days to dry. At a temperature below 4 degrees Celsius and exposed to direct sunlight, there is zero substance,

and in order to preserve the medicinal value of the roots, they store them in polythene bags from drying the roots (Haghighi,2022).

The secondary metabolite plays a defensive role in plant protection against stress factors. They are responsible for herbivores and pathogens. Terpenes or terpenoids are the largest group of secondary metabolites They are included in plants. The most diverse herbal combinations. There are terpenes that are often insoluble in water and from 5 carbon units of isoprene (2 and 5 butadiene) deriv be (Saufi,2007).

This group of secondary metabolites cause odor are. The most common group of secondary metabolites are phenolic compounds. According to the chemical diversity, phenols. They play various roles in the plant and many of them as defensive compounds against herbivores and Pathogens are used. from other roles Phenolic compounds provide mechanical support, attract pollinators, Absorption of harmful ultraviolet rays and antioxidant properties The reduction of the growth of neighboring competing plants can be mentioned (Taiz and Zeiger, 2006).

2. Objectives

In this research, in order to investigate the functional relationship and adaptation characteristics of vetiver root in different conditions and unfavorable environment, including stability in the conditions, soil shear stress in steep slopes was carried out to better understand the adaptation characteristics of the plant root. The characteristics of plant roots in different environments are constantly changing despite the presence of different combinations of mineral elements and the environmental conditions in which they are located. In this research, in order to investigate the functional relationship and adaptation characteristics of vetiver root in different and unfavorable environmental conditions, including stability in conditions, soil shear stress was carried out on steep slopes to better understand the adaptation characteristics of the plant (Mafi et al., 1998; Kolahi and Khatouni, 2021; Ghadampur et al., 2012; Jones et al., 2004). The soil bioengineering method is an environmentally friendly method in which soil stability will be done with the help of vegetation on steep slopes. Vegetation can contribute to the stability of the slope with mechanical and hydrological effects (Bagharian Kalat et al., 2021; Sharifi, 2007; Qawam Arabian, 2007; Khaleghi et al., 2018). The role of vegetation such as vetiver is very important and effective in controlling and reducing runoff and sediments (Asgari et al., 2024). Along the Hemmat-Tehran highway (semi-arid climate) and the side slopes of the Narmab reservoir- Golestan dam, the side slopes of the Sanger-Gilan dam are in three levels with different degrees of slope in each area. First, vegetation analysis. And physicochemical properties including primary phytochemicals, Khusimol, total phenol, total flavonoid and in the second stage of GC-Mass analysis of Khusimol, macroscopic and organoleptic properties, ash solubility were investigated (Azadbakht et al., 2020).

2. Materials and Methods

2.1. Study site

a) The first area studied in this research, a part of Dost-Lat village located in Sangar city, Siahkol city of Gilan province with a slope above 33%. The city of Sangar is located at the end of the Sefid River valley and at the beginning of the Gilan plain. Its average annual temperature is 16 degrees Celsius. Due to its proximity to the Caspian Sea, this province is a region with high humidity and has a moderate and humid climate with a relative humidity between 40 and 100 percent. The amount of rainfall in Gilan province in 2015 when Vetiver plants were planted in the target range was about 1292 mm. Gilan province is located in the north of Iran. It has an area of about 13,952 square kilometers and is located between the coordinates of 36°34'–38°27' N and 48°34'–50°36' E of the Greenwich meridian. The peaks overlooking Gilan from the Alborz mountain range are between 2500 and 3700 meters and the heights of Talash are about 2500 above sea level. This province belongs to the geographical unit south of the Caspian Sea and borders and neighbors with the provinces of Ardabil in the west, Mazandaran in the east, Zanjan in the south and the independent country of Azerbaijan and the Caspian Sea in the north. Sefid Temashk River, which flows between Chabaksar and Ramsar, separates it from Mazandaran province. Gilan province is one of the northern provinces of Iran, centered on the metropolis of Rasht (Figure 1).

b) The second study area in this research is a part of Tehran's Shahid Hemet highway. This region has a semi-arid climate and the average annual temperature of Tehran province is about 17 degrees Celsius and the relative humidity of this region is about 24%. The amount of rainfall in Tehran province in 2014 when Vetiver plants were planted in the target area was about 300.9 mm. According to the country divisions in 2013, Tehran province has an area of about 13,692 square kilometers and is located between the coordinates of 34°42'–36°30' N and 50°42'–50°30' E and this province is bordered by Mazandaran province from the north, Qom province from the south, Qazvin province from the west, and Semnan province from the east; It is capital and one of the most important provinces of the country. In this research, a part of the Shahid Hemet Highway in Tehran with a slope of 34% is considered. This highway reaches Shahid Zainuddin highway from the east side, and then Shahid Zainuddin highway reaches the intersection of Imam Ali highway and finally reaches the multi-story intersection of the three-way test road. It has a semi-arid climate and the average annual temperature of Tehran province is about 17 degrees Celsius and the relative humidity of this area is about 24%. The amount of rainfall in Tehran province in 2015 at the time of Vetiver planting in the target range was about 300.9 mm. The highest altitude of Tehran province is in the northwest with an altitude of 2985 meters and the lowest altitude is in the southwest with an altitude of 753 meters (Figure 2).

c) The third researched area is a part of the lands bordering the Narmab dam in Minodasht and is located between the coordinates of 36°25'–38°8' N and 53°50'–56°11' E in Golestan province with a slope above 45%. Minodasht city with 700 square kilometers occupies 4.2% of the land of Golestan province and is located in the eastern part of the province and is 110 kilometers away from the center of the province (Gorgan). The climate of mountainous Minodasht is mild and humid, and the highest and lowest temperatures are reported as 45 degrees above zero and 2 degrees below zero, respectively. The relative humidity of this area is between 41 and 68%. Also, the average annual rainfall is about 450 mm. The mountainous region of this region beyond 3000 meters includes the high mountains of the Alborz slopes, with long frosts and cold winters and short and cool summers with a climate specific to the

highlands. The amount of rainfall in Golestan province in 2015 when Vetiver plants were planted in this range was about 450 mm. This province is one of the northern provinces of Iran, which borders North Khorasan province from the east, Semnan province from the south, Mazandaran from the west, and Turkmenistan from the north (Figure 3).

2.2. Preliminary Phytochemical Analysis

The collected plant samples were transferred to the laboratory environment. They were dried in the shade at room temperature to prepare for future analyses. To prepare extracts, they were extracted separately from methanol/water (80/20) solvents by maceration method. They were condensed using a rotary machine and prepared as viscous powders with a freeze dryer machine. The extracts are kept at a temperature of 4 degrees Celsius until analysis. To identify the alkaloids, first the extracts were mixed with 5 drops (1%) of HCL in a test tube and then heated separately for 10 minutes. After cooling, 5 drops of Wagner's reagent and Mayer's reagent were poured separately into the mixture, and finally observing a reddish-brown precipitate with Wagner's reagent, and a creamy yellow precipitate with Mayer's reagent will indicate the presence of alkaloid. To detect phenolic compounds, first the extracts are mixed with 5 drops of FeCl₃ solution (0.1%) and finally, it is indicated by the observation of gray or blue color. To detect the presence of tannins and phenolic compounds, the extracts were mixed separately with 5 drops of FeCl₃ solution (0.1%) and the final color, greenish-brown or blue-black, indicates the presence of tannins. For flavonoids, the extracts were mixed separately using 2 ml of NaOH (0.5)% and 5 drops of HCl (1%) and then a small amount of magnesium powder was added to it, the observation of red or pink color indicates the presence It is a flavonoid. For anthraquinones, the extracts were mixed separately with 5 ml of hydrochloride (1%) and 5 ml of benzene, and then 2 ml of NH₄OH solution (10%) was added, observing a pinkish-purple or red color. In the NH₄OH phase, it indicates its presence. For coumarins, the extracts were mixed separately with 5 ml of NaOH solution (10%) and the observation of a blue-green fluorescence color indicates the presence of coumarins. For saponins, the extracts should be mixed separately with 5 ml of distilled water. After that, it is vigorously shaken for 5 minutes. The formation of stable foam indicates the presence of saponins. For terpenoids and steroids, the extracts were mixed with 5 ml of chloroform separately, and then 5 ml of concentrated H₂SO₄ was added to the solution. Finally, seeing a red-brown ring indicates terpenoids. In addition, the red color in the extract mixed with concentrated H₂SO₄ indicates steroids. For glycosides, the extracts were mixed with 5 ml of acetic acid (50%) and 5 ml of H₂SO₄ (3%), red color indicates glycoside.

2.3. Total Analysis of Phytoconstituents

Evaluation of the amount of total flavonoids in optimal conditions for 12 samples was determined by the spectrophotometric method of aluminum chloride. At this stage, 0.5 milliliters of the extract is mixed with 1.5 milliliters of ethanol and mixed with 0.1 milliliters of 10% aluminum chloride methanolic solution and again 0.1 milliliters of one molar potassium acetate. We add At the end, 2.8 ml of distilled water is added and after mixing, it is placed in the ambient conditions of the room for 30 minutes, and finally, the absorbance of the samples is read against the blank in the UV-visib device with a wavelength of 415 nm.

Evaluation of the amount of total phenol in optimal conditions for 36 samples was determined by the spectrophotometric method of Folin Cicalto reagent. At this stage, the value of 0.5 ml of the extract separately with 2.5 cc of Folin Cicalto's reagent (diluted with distilled water at a ratio of 1:10), after 5 to 10 minutes, 2 cc of 7.5% sodium carbonate is added to it and for a period of 30 We keep it away from light in a dark space for a minute. Finally, the absorbance of the samples against the blank is read in the UV-vis device with a wavelength of 765 nm.

2.4. GC-Mass Analysis of Khusimol

GC-MASS instrument with helium flow rate of 1 mL/min and tube size of 30 m with Hp5-MS stationary phase, temperature is initially 90°C for one minute to 130°C at a rate of 30°C. /min and a speed of 10 °C/min to 280 °C for 15 min was performed for Khusimol analysis.

2.5. Physicochemical Properties

The organoleptic properties of medicinal plants include the appearance, smell, taste and sound of breaking the dry plant organ, which has a unique state in each medicinal plant. Therefore, these properties can be evaluated by the individual's sensory organs, and due to the stability of each one, it can be used in pharmacopoeial studies.

Samples (36 samples) of Vetiver roots (*chrysopogon zizanioides*) after drying were analyzed in terms of organoleptic properties including color, taste, smell and structural shape. At this stage, the foreign substances in the powder (36 samples) of vetiver roots (*chrysopogon zizanioides*) were evaluated and quantified. For this purpose, 1 gram of each sample was individually powdered and on a plate in a wide thin layer and foreign materials were examined and separated with the naked eye. This work was repeated three times for each sample and the results were reported as mean percentage $\pm$ standard deviation.

In pharmacopoeias, the humidity or the amount of water in the sample plays an essential role in controlling the quality of the drug, and its amount should not be higher than normal. An increase in the product causes fungal and insect contamination and causes spoilage of the raw material and the final formulation. For this purpose, the amount of moisture in the raw material should be reduced at first with reliable methods. Also, in the process of preparing the raw material, the necessary precautions should be taken into account in all stages of collection, drying and packaging. The dried limbs did not break easily and the sound of breaking the roots is not clearly heard. In order to determine the percentage of moisture in this step, we put 0.5 grams of powder (36 samples) of the roots of the vetiver plant (*chrysopogon zizanioides*) separately in a Chinese vase (the Chinese vases are preheated for one hour at 105 degrees Centigrade was set to reach a constant weight and the cruises were re-weighed. Then, the flasks containing the samples were placed in an electric oven at 105°C for one hour and then placed in a desiccator to cool. Finally, the containers containing the samples were weighed. The difference in weight indicated the amount of moisture in the roots of vetiver plant (*chrysopogon zizanioides*). This work was

repeated 3 times for each sample and the results were reported as mean percentage $\pm$ standard deviation.

First, the Chinese crucible is placed at 105 degrees Celsius for one hour to reach a constant weight. Then, to determine the amount of total ash, 0.5 grams of vetiver root powder (*chrysopogon zizanioides*) was poured separately into a porcelain mug and placed in an electric furnace at a temperature of 600 degrees Celsius for 6 hours until they were completely reduced to ash. . Then put the crucibles containing ash in a desiccator to cool and reach a constant weight. The obtained ash weight represented the percentage of total ash in each sample.

To determine acid-insoluble ash, 12.5 cc of distilled water and 2.5 cc of 35% hydrochloric acid were added to each sample of total ash and boiled for 5 minutes. Then each sample was filtered with filter paper and the ash on the filter paper was washed several times. Finally, the amount of ash remaining on each filter paper was weighed separately. The weight of this obtained ash indicates the percentage of ash insoluble in acid.

Finally, the difference in the weight of total ash and water-insoluble ash indicates the percentage of water-soluble ash. These steps were repeated 3 times for each plant and the results were reported as mean $\pm$ percent standard deviation.

The degree of solubility in the powder of each herbal medicinal organ and in different solvents has a very close relationship with their constituent compounds, and considering that the more polar the amount of compounds in the organ is, the solubility in more polar solvents such as methanol And there is more water. Also, the more non-polar compounds are, the higher the solubility in non-polar solvents. On the other hand, with the alkalinity of the compounds, the solubility in acidic solvents increases, and with their acidity, the solubility in the alkaline solvent increases. This feature is unique in the medicinal organs of each plant and for this reason it is used in pharmacopoeial studies.

In order to check the solubility of vetiver root powder (*chrysopogon zizanioides*), they were mixed separately in water, pure methanol, 96% ethanol, chloroform, hexane, 10% potassium hydroxide solution and 5% sulfuric acid solution. This step can be performed at room temperature without the use of a sonicator with any device that aids in solubilization. (Figure 4)

3. Results

3.1. GILAN

In this part of the research, the root of vetiver plant is mentioned on three levels with different degrees of slope from the side slopes overlooking the Sangar dam reservoir with the aim of determining the physicochemical properties of the plant (Table 1).

Table 1. Physicochemical findings of Vetiver plant root (side areas of Sangar Dam - Gilan).

chrysopogon zizanioides		Level (30-40 degrees)	Level (40-50 degrees)	Level (60-70 degree)
Characteristics				
Organoleptic Properties	Shape	Globular to Oval	Globular to Oval	Globular to Oval
	Powder Colour	White to Brown	White to Brown	Gray to Brown
	Odour	Mild	Mild	Mild
	Taste	Sweet	Sweet	Sweet
Solubility	Water	Insoluble	Insoluble	Insoluble
	KOH 10%	Sparingly Soluble	Sparingly Soluble	Sparingly Soluble
	H ₂ SO ₄ 5%	Solution	Solution	Solution
	Metanol	Freely Soluble	Freely Soluble	Freely Soluble
	Ethanol 96%	Freely Soluble	Freely Soluble	Solution
	Chloroform	Freely Soluble	Freely Soluble	Solution
	Hexane	Freely Soluble	Freely Soluble	Solution
Foreign Matter (%)		2.8±0.67	2.5±0.67	1.9±0.33
Moisture Content (%)		12.8±1.43	12.06±1.43	8.45±0.47
Ash Content (%)	Total Ash	1.50±0.88	1.52±0.38	2.82±0.098
	Acid Insoluble Ash	1.54±0.98	1.59±0.98	1.62±0.67
	Water Insoluble Ash	1.74±0.09	1.77±0.5	2.98±0.06
	Water Soluble Ash	1.26±0.03	1.20±0.01	1.16±0.05

The results obtained from the organoliptic feature - appearance in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with the degree of soil slope (60-70 degrees) are respectively (spherical to oval), (spherical to oval) and (spherical to oval).

The results obtained from the organoliptic characteristic - powder color on the first level with the slope of the soil slope (30-40 degrees), on the second level with the slope of the soil slope (40-50 degrees) and

on the third level with the degree of soil slope (60-70 degrees) are respectively (white to brown), (white to brown) and (gray to brown).

The obtained results of the organoliptic characteristic - aroma and smell in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with the degree of soil slope. (60-70 degrees) are respectively (mild), (mild) and (mild).

The results obtained from the organoliptic-taste characteristics in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with the soil slope degree (60 - 70 degrees) are respectively (Sweet), (Sweet) and (Sweet).

The obtained results of the property of solubility in water in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with the degree of soil slope (60-70 degrees) are respectively (insoluble), (insoluble) and (insoluble).

The results obtained from the property of solubility in 10% potassium hydroxide in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with The degree of soil slope (60-70 degrees) is respectively (low solubility), (low solubility) and (low solubility).

The results obtained from the characteristic of solubility in 5% sulfuric acid in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with The degree of soil slope (60-70 degrees) is respectively (dissolved), (dissolved) and (dissolved).

The results obtained from the characteristic of solubility in methanol in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with the degree of soil slope (60-70 degrees) respectively (easily solvable), (easily solvable) and (easily solvable).

The results obtained from the characteristic of solubility in 96% ethanol in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with The slope of the soil (60-70 degrees) is respectively (easily soluble), (easily soluble) and (dissolvable).

The results obtained from the property of solubility in chloroform on the first level with the slope of the soil slope (30-40 degrees), on the second level with the slope of the soil slope (40-50 degrees) and the third level with the degree of soil slope (60-70 degrees) respectively (easily soluble), (easily soluble) and (soluble).

The results obtained from the characteristic of solubility in hexane in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the

third level with the degree of soil slope (60-70 degrees) respectively (easily soluble), (easily soluble) and (soluble).

The results obtained from the characteristics of foreign material (percentage) in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with the degree of soil slope. (60-70 degrees) are (0.67 ± 2.8) , (0.67 ± 2.5) and (0.33 ± 1.9) , respectively.

The results obtained from the characteristics of moisture content (percentage) in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with the degree of soil slope (60-70 degrees) are (1.43 ± 12.8) , (1.43 ± 12.06) and (0.47 ± 8.45) , respectively.

The results obtained from the characteristic of total ash (percentage) in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with the degree of soil slope (60-70 degrees) are (0.88 ± 1.50) , (0.38 ± 1.52) and (0.098 ± 2.82) , respectively.

The results obtained from the characteristics of ash insoluble in acid (percent) in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and in the third level with The soil slope (60-70 degrees) is (0.98 ± 1.54) , (0.98 ± 1.59) and (0.67 ± 1.62) , respectively.

The results obtained from the characteristics of water insoluble ash (percent) in the first level with the slope of the soil (30-40 degrees), in the second level with the slope of the soil (40-50 degrees) and the third level with The soil slope (60-70 degrees) is (1.74 ± 0.09) , (1.77 ± 0.5) and (2.98 ± 0.06) , respectively.

The results obtained from the characteristics of ash soluble in water (percentage) in the first level with the slope of the soil slope (30-40 degrees), in the second level with the slope of the soil slope (40-50 degrees) and the third level with The soil slope (60-70 degrees) is (1.26 ± 0.03) , (1.20 ± 0.01) and (1.16 ± 0.05) , respectively (Table 1).

The results of the qualitative investigation of chemical compounds (presence or absence) in the three studied areas are stated (Table 2).

Table 2. The results of qualitative review of compounds.

crysopogon zizaniodes Compounds	Gilan	Tehran	Golestan
Alkaloids	+	+	+
Phenolic compounds	+	+	+
Tannins	+	+	+
Flavonoids	+	+	+
Anthraquinones	+	+	+
Coumarins	+	+	+
Saponins	+	+	+
Terpenoids	+	+	+
Steroids	+	+	+
Glycosides	+	+	+

The results of primary phytochemical studies and the general measurement of plant compounds in vetiver root extract in three regions with different climates and different degrees of slopes, similar compounds were detected in them. The presence of alkaloids, phenolic compounds, tannins, flavonoids, coumarins, saponins, terpenoids, steroids, anthraquinones and glycosides were detected.

In the following tables, the results of the separation and determination of total phenol, flavonoid and khusimol are presented (Table 3).

Table 3. The results of determining the amount of khusimol substance, the total content of phenolic compounds and flavonoids (Sangar-Gilan Dam side range).

chrysopogon zizanioides Compounds	Level (30-40 degrees)	Level (40-50 degrees)	Level (60-70 degrees)
Khusimol (μlit Khusimol/100 g corm)	0.342 $\pm$ 0.043	0.515 $\pm$ 0.020	0.662 $\pm$ 0.26
Total phenol contents (g galic acid/100 g corm)	0.195 $\pm$ 0.026	0.254 $\pm$ 0.022	0.301 $\pm$ 0.052
Total flavonoid contents (g galic acid/100 g corm)	0.176 $\pm$ 0.055	0.288 $\pm$ 0.023	0.404 $\pm$ 0.015

The results obtained from determining the amount of Khusimol, total phenolic compounds and flavonoids per 100 grams of roots in the side slopes of Sangar Dam reservoir located in Gilan province are as follows (Table 3):

The amount of khusimol substance in the first level of the side slope of Sangar-Gilan dam reservoir (30-40 degrees) is this value (0.043 $\pm$ 0.342 μ lit). The amount of khusimol substance in the second level of the side slope of Sangar-Gilan dam reservoir (40-50 degrees) is this amount (0.515 $\pm$ 0.020 μ lit). The amount of khusimol substance in the third level of the side slope of Sangar-Gilan dam reservoir (60-70 degrees) is this value (0.662 $\pm$ 0.026 μ lit).

The amount of total phenolic compounds in the first level of the side slope of Sangar-Gilan dam reservoir (30-40 degrees) is this value (0.195 $\pm$ 0.026 μ lit). The amount of total phenolic compounds in the second level of the side slope of Sangar-Gilan dam reservoir (40-50 degrees) is this value (0.254 $\pm$ 0.022 μ lit). The amount of total phenolic compounds in the third level of the side slope of Sangar-Gilan dam reservoir (60-70 degrees) is this value (0.052 $\pm$ 0.301 μ lit).

The amount of flavonoids in the first level of the side slope of Sangar-Gilan dam reservoir (30-40 degrees) is this value (0.176 $\pm$ 0.055 μ l). The amount of flavonoids in the second level of the side slope of Sangar-Gilan dam reservoir (40-50 degrees) is this value (0.288 $\pm$ 0.023 μ l). The amount of flavonoids in the third level of the side slope of Sangar-Gilan dam reservoir (30-40 degrees) is this value (0.404 $\pm$ 0.015 μ l).

The amount of khusimol based on the calibration curve) on the first level of the side slopes of the Sanger-Gilan dam with the slope of the soil slope (30-40 degrees) is a numerical value (96175830.58 μ g/ml). According to the calibration curve, the amount of khusimol in the second level of the side slopes of the Sanger-Gilan dam with the slope of the soil slope (40-50 degrees) is a numerical value (2574323747 μ g/ml). According to the calibration curve, the amount of Khusimol in the third level of the side slopes of the Sanger-Gilan dam with the slope of the soil slope (60-70 degrees) is numerical value (3255163747 μ g/ml) (Figure 8).

3.2. Tehran

In this part of the research, the roots of vetiver plant are mentioned on three levels with different degrees of slope from the sloping domain of Hemmat-Tehran highway with the aim of determining the physicochemical characteristics of the plant (Table 4).

Table 4. Physicochemical findings of Vetiver root (sloping area of Hemet-Tehran highway).

chrysopogon zizanioides		Level (40-50 degrees)	Level (70-80 degrees)	Level (80-90 degrees)
Characteristics				
Organoleptic Properties	Shape	Globular to Oval	Globular to Oval	Globular to Oval
	Powder Colour	White to Brown	Gray to Brown	Brown
	Odour	Mild Spicy	Spicy	Spicy
	Taste	Sweet	Sweet	Sweet
Solubility	Water	Insoluble	Insoluble	Insoluble
	KOH 10%	Sparingly Soluble	Sparingly Soluble	Sparingly Soluble
	H₂SO₄ 5%	Solution	Solution	Sparingly Soluble
	Metanol	Freely Soluble	Freely Soluble	Solution
	Ethanol 96%	Solution	Solution	Sparingly Soluble
	Chloroform	Solution	Sparingly Soluble	Sparingly Soluble
	Hexane	Solution	Sparingly Soluble	Sparingly Soluble
Foreign Matter (%)		1.08±0.54	1.03±0.54	1.01±0.34
Moisture Content (%)		2.5±0.87	1.8±0.87	1.4±0.67
Ash Content (%)	Total Ash	2.07±1.02	3.01±1.02	4.2±0.098
	Acid Insoluble Ash	1.87±0.88	2.01±0.88	2.42±0.56
	Water Insoluble Ash	0.7±0.7	0.84±0.72	3.13±0.86
	Water Soluble Ash	1.24±0.05	1.07±0.05	1.04±0.06

The results obtained from the organoleptic feature - appearance in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope. (80-90 degrees) are respectively (spherical to oval), (spherical to oval) and (spherical to oval).

The results obtained from the organoleptic characteristic - powder color on the first level with the slope of the soil slope (40-50 degrees), on the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are (white to brown), (gray to brown) and (brown) respectively.

The results obtained from the organoleptic characteristic - fragrance and aroma in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope. (80-90 degrees) are (mild to hot), (hot) and (hot) respectively.

The results obtained from the organoleptic-taste characteristic in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the soil slope degree (80 - 90 degrees) are respectively (Sweet), (Sweet) and (Sweet).

The obtained results of the property of solubility in water in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are respectively (insoluble), (insoluble) and (insoluble).

The results obtained from the property of solubility in 10% potassium hydroxide in the first level with the slope of the soil (40-50 degrees), in the second level with the slope of the soil (70-80 degrees) and the third level with The degree of soil slope (80-90 degrees) is respectively (low solubility), (low solubility) and (low solubility).

The results obtained from the characteristic of solubility in 5% sulfuric acid in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with The degree of soil slope (80-90 degrees) is respectively (dissolved), (dissolved) and (slightly soluble).

The results obtained from the characteristic of solubility in methanol in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) respectively (easily soluble), (easily soluble) and (soluble).

The results obtained from the characteristic of solubility in 96% ethanol in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with The slope of the soil (80-90 degrees) is respectively (dissolved), (dissolved) and (slightly soluble).

The results obtained from the property of solubility in chloroform on the first level with the slope of the soil slope (40-50 degrees), on the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are respectively (soluble), (slightly soluble) and (slightly soluble).

The results obtained from the characteristic of solubility in hexane in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are respectively (soluble), (slightly soluble) and (slightly soluble).

The results obtained from the characteristics of foreign material (percentage) in the first level with the slope of the soil slope (40-50 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are (0.54 ± 1.08) , (0.54 ± 1.03) and (0.34 ± 1.01) , respectively.

The results obtained from the characteristics of moisture content (percentage) in the first level with the slope of the soil (40-50 degrees), in the second level with the slope of the soil (70-80 degrees) and the third level with the degree of soil slope. (80-90 degrees) are (0.87 ± 2.5) , (0.87 ± 1.8) and (0.67 ± 1.4) , respectively.

The results obtained from the characteristic of total ash (percentage) in the first level with the soil slope (40-50 degrees), in the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are (1.02 ± 2.07) , (1.02 ± 3.01) and (0.098 ± 4.2) , respectively.

The results obtained from the characteristics of ash insoluble in acid (percentage) in the first level with the soil slope (40-50 degrees), in the second level with the soil slope (70-80 degrees) and the third level with The soil slope (80-90 degrees) is (0.88 ± 1.87) , (0.88 ± 2.01) and (0.56 ± 2.42) , respectively.

The results obtained from the characteristic of water insoluble ash (percentage) in the first level with the soil slope (40-50 degrees), in the second level with the soil slope (70-80 degrees) and the third level with The soil slope (80-90 degrees) is (0.7 ± 0.7) , (0.72 ± 0.84) and (0.86 ± 3.13) , respectively (Table 4).

In the following tables, the results of isolation and determination of total phenol, flavonoid and khusimol in the slope of Hemet-Tehran highway are presented (Table 5).

Table 5. The results of determining the amount of khusimol substance, the total content of phenolic compounds and flavonoids (Hemet-Tehran highway area).

chrysopogon zizanioides Compounds	Level (40-50 degrees)	Level (70-80 degrees)	Level (80-90 degrees)
Khusimol (μlit Khusimol/100 g corm)	0.642 $\pm$ 0.053	0.725 $\pm$ 0.040	0.982 $\pm$ 0.34
Total phenol contents (g galic acid/100 g corm)	0.395 $\pm$ 0.027	0.426 $\pm$ 0.034	0.562 $\pm$ 0.042
Total flavonoid contents (g galic acid/100 g corm)	0.296 $\pm$ 0.085	0.325 $\pm$ 0.028	0.481 $\pm$ 0.019

The results of determining the amount of khusimol, total phenolic compounds and flavonoids per 100 grams of roots in the area of Hemet highway located in Tehran province are as follows (Table 5):

The amount of Khusimol substance in the first level of the Hemet-Tehran highway slope (40-50 degrees) is this value (0.053 $\pm$ 0.642 μ lit). The amount of khusimol substance in the second level of the slope of Hemet-Tehran highway (60-70 degrees) is this value (0.725 $\pm$ 0.040 μ lit). The amount of khusimol substance in the third level of the slope of Hemet-Tehran highway (80-90 degrees) is this value (0.982 $\pm$ 0.034 μ lit).

The amount of total phenolic compounds in the first level of the Hemet-Tehran highway slope (40-50 degrees) is this value (0.027 $\pm$ 0.395 μ lit). The amount of total phenolic compounds in the second level of the slope of Hemet-Tehran highway (60-70 degrees) is this value (0.034 $\pm$ 0.426 μ lit). The amount of total phenolic compounds in the third level of the slope of Hemet-Tehran highway (80-90 degrees) is this value (0.042 $\pm$ 0.562 μ lit).

The amount of flavonoids in the first level of the Hemet-Tehran highway slope (40-50 degrees) is this value (0.296 $\pm$ 0.085 μ lit). The amount of flavonoids in the second level of the Hemet-Tehran highway slope (60-70 degrees) is this value (0.028 $\pm$ 0.028 μ l). The amount of flavonoids in the third level of the Hemet-Tehran highway slope (80-90 degrees) is this value (0.481 $\pm$ 0.019 μ l), (Table 5).

The amount of khusimol based on the calibration curve) on the first level of the slope of Hemet-Tehran highway with the soil slope (40-50 degrees) is a numerical value (1819160831 μ g/ml). The amount of khusimol based on the calibration curve) on the second level of the slope of the Hemet-Tehran highway with the slope of the soil slope (70-80 degrees) is a numerical value (3543740414 μ g/ml). The amount of khusimol based on the calibration curve) on the third level of the slope of the Hemet-Tehran highway with the slope of the soil slope (80-90 degrees) is a numerical value (5460021664 μ g/ml), (Figure 9):

3.3. Golestan

In this part of the research, the roots of vetiver plant are mentioned in three levels with different degrees of slope from the side slope of Narmab-Golestan dam with the aim of determining the physicochemical characteristics of the plant.. (Table 6).

Table 6. Physicochemical findings of Vetiver root (side range of Narmab Dam- Golestan).

chrysopogon zizanioides		Level (60-70 degrees)	Level (70-80 degrees)	Level (80-90 degrees)
Characteristics				
Organoleptic Properties	Shape	Globular to Oval	Globular to Oval	Globular to Oval
	Powder Colour	White to Brown	White to Brown	Brown
	Odour	Mild	Mild Spicy	Spicy
	Taste	Sweet	Sweet	Sweet
Solubility	Water	Insoluble	Insoluble	Insoluble
	KOH 10%	Sparingly Soluble	Sparingly Soluble	Sparingly Soluble
	H₂SO₄ 5%	Solution	Solution	Solution
	Metanol	Freely Solution	Solution	Solution
	Ethanol 96%	Sparingly Soluble	Sparingly Soluble	Sparingly Soluble
	Chloroform	Sparingly Soluble	Solution	Solution
	Hexane	Sparingly Soluble	Solution	Solution
Foreign Matter (%)		2.4±0.67	1.9±0.55	1.4±0.44
Moisture Content (%)		8.45±1.43	7.5±0.77	6.45±0.66
Ash Content (%)	Total Ash	2.98±0.88	3.71±1.02	4.32±0.098
	Acid Insoluble Ash	2.64±0.98	2.74±0.88	2.92±0.58
	Water Insoluble Ash	2.67±0.88	2.97±0.71	4.23±0.86
	Water Soluble Ash	1.06±0.04	1.04±0.08	1.03±0.08

The results obtained from the organoleptic characteristic - appearance in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are respectively (spherical to oval), (spherical to oval) and (spherical to oval).

The results obtained from the organoleptic characteristic - powder color on the first level with the slope of the soil slope (60-70 degrees), on the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are (white to brown), (white to brown) and (brown) respectively.

The results obtained from the organoleptic characteristic - aroma and smell in the first level with the soil slope (60-70 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are (mild), (mild to hot) and (hot) respectively.

The results obtained from the organoleptic-taste characteristics in the first level with the soil slope (60-70 degrees), in the second level with the slope of the soil slope (70-80 degrees) and the third level with the soil slope degree (80 - 90 degrees) are respectively (Sweet), (Sweet) and (Sweet).

The obtained results of the property of solubility in water in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are respectively (insoluble), (insoluble) and (insoluble).

The results obtained from the property of solubility in 10% potassium hydroxide in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with The degree of soil slope (80-90 degrees) is respectively (low solubility), (low solubility) and (low solubility).

The results obtained from the characteristic of solubility in 5% sulfuric acid in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with The degree of soil slope (80-90 degrees) is respectively (dissolved), (dissolved) and (dissolved).

The results obtained from the characteristic of solubility in methanol in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are respectively (easily soluble), (soluble) and (soluble).

The results obtained from the characteristic of solubility in 96% ethanol in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with The slope of the soil (80-90 degrees) is respectively (low solubility), (low solubility) and (low solubility).

The results obtained from the property of solubility in chloroform on the first level with the soil slope (60-70 degrees), on the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are respectively (slightly soluble), (dissolved) and (dissolved).

The results obtained from the characteristic of solubility in hexane on the first level with the soil slope (60-70 degrees), on the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are respectively (slightly soluble), (dissolved) and (dissolved).

The results obtained from the characteristics of foreign matter (percent) in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are (0.67 ± 2.4) , (0.55 ± 1.9) and (0.44 ± 1.4) , respectively.

The results obtained from the characteristics of moisture content (percent) in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are (1.43 ± 8.45) , (0.77 ± 7.5) and (6.45 ± 0.66) , respectively.

The results obtained from the characteristics of total ash (percentage) in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with the degree of soil slope (80-90 degrees) are (2.98 ± 0.88) , (3.71 ± 0.02) and (4.32 ± 0.098) , respectively.

The results obtained from the characteristics of ash insoluble in acid (percent) in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with The soil slope (80-90 degrees) is (0.98 ± 2.64) , (0.88 ± 2.74) and (0.58 ± 2.92) , respectively.

The results obtained from the characteristic of water insoluble ash (percentage) in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with The soil slope (80-90 degrees) is (0.88 ± 2.67) , (0.71 ± 2.97) and (0.86 ± 4.23) , respectively.

The results obtained from the properties of ash soluble in water (percent) in the first level with the soil slope (60-70 degrees), in the second level with the soil slope (70-80 degrees) and the third level with The soil slope (80-90 degrees) is (0.04 ± 1.06) , (0.08 ± 1.04) and (0.08 ± 1.03) , respectively (Table 6).

In the following tables, the results of isolation and determination of total phenol, flavonoid and khusimol in the slope of Hemet-Tehran highway are presented (Table 7):

Table 7. The results of determining the amount of khusimol substance, the total content of phenolic compounds and flavonoids (Narmab-Golestan side area).

chrysopogon zizanioides Compounds	Level (60-70 degrees)	Level (70-80 degrees)	Level (80-90 degrees)
Khusimol (μlit Khusimol/100 g corm)	0.739 $\pm$ 0.033	0.891 $\pm$ 0.036	0.956 $\pm$ 0.74
Total phenol contents (g galic acid/100 g corm)	0.560 $\pm$ 0.021	0.648 $\pm$ 0.019	0.723 $\pm$ 0.076
Total flavonoid contents (g galic acid/100 g corm)	0.357 $\pm$ 0.037	0.482 $\pm$ 0.032	0.581 $\pm$ 0.035

The results obtained from determining the amount of khusimol, total phenolic compounds and flavonoids per 100 grams of roots in the side slope of the Narmab dam reservoir located in Golestan province are as follows (Table 7):

The amount of Khusimol substance in the first level of the side slope of Narmab-Golestan dam reservoir (60-70 degrees) is this amount (0.033 $\pm$ 0.739 μ lit). The amount of Khusimol substance in the second level of the side slope of Narmab-Golestan dam reservoir (70-80 degrees) is this amount (0.891 $\pm$ 0.036 μ lit). The amount of Khusimol substance in the third level of the side slope of Narmab-Golestan dam reservoir (80-90 degrees) is this value (0.956 $\pm$ 0.074 μ lit).

The amount of total phenolic compounds in the first level of the side slope of the Normab-Golestan reservoir (60-70 degrees) is this value (0.560 $\pm$ 0.021 μ lit). The amount of total phenolic compounds in the second level of the side slope of Narmab-Golestan dam reservoir (70-80 degrees) is this value (0.648 $\pm$ 0.019 μ l). The amount of total phenolic compounds in the third level of the side slope of Narmab-Golestan dam reservoir (80-90 degrees) is this value (0.076 $\pm$ 0.076 μ lit).

The amount of flavonoids in the first level of the side slope of Narmab-Golestan dam reservoir (60-70 degrees) is this value (0.357 $\pm$ 0.037 μ lit). The amount of flavonoids in the second level of the side slope of Narmab-Golestan reservoir (70-80 degrees) is this value (0.482 $\pm$ 0.032 μ l). The amount of flavonoids in the third level of the side slope of Narmab-Golestan dam reservoir (80-90 degrees) is this value (0.581 $\pm$ 0.035 μ l) (Table 7).

The amount of khusimol based on the calibration curve) on the first level of the side slope of Narmab-Golestan dam with the slope of the soil slope (60-70 degrees) is a numerical value (3354215831 μ g/ml). The amount of khusimol based on the calibration curve) on the second level of the side slope of Narmab-Golestan dam with the slope of the soil slope (70-80 degrees) is a numerical value (9394264581 μ g/ml). The amount of khusimol based on the calibration curve) on the third level of the side slope of Narmab-Golestan dam with the slope of the soil slope (80-90 degrees) is numerical value (99208120227 μ g/ml), (Figure 10).

4. Discussion

Finally, according to the results of this research, it can be concluded that it increases or decreases the amount of plant extracts in high altitudes and slopes according to their adaptability, and the high potential of vetiver plant in increasing shear resistance. Soil is a strong reason for its intelligent operation.

The results of this research with the results of some researchers, including Nabavi et al (2014) in a research entitled the effect of soil and altitude on the active substance of *Juniperus communis* species in Mazandaran province., Gholamhosseinzadeh et al (2014) in a research titled investigating the effect of altitude on the amount and composition of mountain thyme essential oil in Pleur region- Amol city, on *Kotschyianus Thymus* species to investigate the effect of altitude on growth and genetic and ecological conditions., Aalipour et al (2014) in a research entitled "Investigation of the effect of environmental conditions on the quantity and quality of essential oil of *Stachys laxa*", investigated the effect of environmental factors (slope, soil) on the quantity and quality of essential oil of *Stachys laxa* species in Mazandaran province., Parsa (2014) in a research on the effect of some environmental factors on changes in the vegetation of pastures in Jashlobar summer area in Semnan province, Mehrpour et al (2015) Different medicinal plants of *Ferula assafoetida* L. in two natural habitats of Semnan and Khorasan provinces, Bahraini Nejad and Mirza (2017) in a research titled investigating the effect of ecological factors on essential oil compositions of different genotypes of *Thymus daenensis* (*Thymus daenensis*) Celak) using the Raj Bandi technique in Isfahan province, Panbehkar et al (2017) in a research titled phytochemical investigation, measurement of phenolic compounds and antioxidant capacity of vetiver root extract (*chrysopogon zizanioides*) in Khuzestan province, Saleh et al. (2018) in a research on the effect of environmental factors on the amount of effective substances of *Nepeta asterotricha* Rech.f using the reduction analysis method, in Yazd province, Azad-Bakht et al. Physicochemical and biological activity of three species of *Colchicum* in Mazandaran, Nazarpur and Yadgari provinces (1400) in a research entitled Ecophytochemical investigation of the essential oil of three species of medicinal plants. *Artemisia* L affected by climate and different phenological stages in Khuzestan province, corresponds. Emphasizing the important principle that secondary metabolites change under the influence of various climatic factors and increase under harsh environmental conditions. From the results of this research with the results of some researches conducted, including Haider et al. Haider et al (2009) on the efficiency of *Artemisia roxburghiana* essential oil in the pastures of the Himalayas, and Azarnivand et al. Azarnivand et al (2010) about the yield of yarrow essential oil *Achillea millefolium* in Siah Bisheh habitat of Mazandaran province and Arianfar et al (2016) on *Artemisia aucheri* Boiss and *Artemisia sieberi* Besser species in South Khorasan and Truong and Baker (1998) on wormwood species in Swad Kah region, and states that the yield decreases with increasing altitude. Considering that with the increase of the altitude factor, only some plants are able to increase their secondary metabolite (PolakiKhoshkroudi et al., 2023).

5. Conclusions

In this research, Physicochemical properties of vetiver root (*chrysopogon zizanioides*) including macroscopic and organoleptic properties, ash values and solubility in acid and water were evaluated. Different organoleptics and macroscopic properties such as color, smell, taste and powder form were also evaluated.

- The macroscopic and organoleptic properties of vetiver roots, including color, smell, taste and powder form in the side slopes of Sangar dam, are as follows: the dried root powder is white in color, has a mild aroma, sweet taste and The shape is oval to spherical. In terms of solubility in insoluble water and solubility in acid, it is lower than the samples of Hemmat-Tehran highway and Narmab-Golestan dam slopes.
- The macroscopic and organoleptic properties of the Hemet-Tehran highway area are as follows: the dried powder of the root is white-brown in color, aromatic, pungent smell, sweet taste and oval to spherical in shape.
- The macroscopic and organoleptic properties of Sednarmab-Golestan side range are as follows: the dried powder of the root is white-brown in color, aromatic, almost pungent smell, sweet taste and oval to spherical shape.

Also in this research, Khusimol substance was evaluated as one of the main and important compounds of vetiver plant (*chrysopogon zizanioides*) from the group of sesqui terpenes under the influence of changes in soil factors, slope, and altitude. With the increase in slope and height in three areas (sloping area of Hemmat-Tehran highway, side slopes of Sangar dam reservoir and side slopes of Narmab dam reservoir - Golestan), the amount of Khusimol substance in essential oils also increased. The percentage of clay is the most important factor affecting the amount of Khusimol in all three regions. By increasing the percentage of clay and soil acidity in the steep and high slopes, the vetiver plant increases its biological activity. In this way, Sesquiterpene compounds, including Khusimol, increase. In fact, vetiver plant structure reacts well to adverse and harsh environmental conditions. The biological activity of vetiver plant increases in difficult conditions in order to increase its adaptability and durability. In addition to measuring and determining the level of Khusimol in the essential oil of vetiver roots, the weight of vetiver root extracts was also determined. The weight of the extract also increased in the same order.

Declarations

Authors' Contribution:

Sahel Haghighi was the principal investigator of this study who participated in data collection and critically revised the manuscript. Research researchers Prof. Mohammad Azadbakht and Prof. Forood Sharifi participated in data collection and critically reviewed the manuscript. Reza Tamartash revised the manuscript.

Conflict of Interests:

The authors declare that there is no conflict of interest.

Funding/Support:

Mazandaran University of Medical Sciences and Soil Conservation and Watershed Research Institute supported this research.

Acknowledgments: We hereby express our gratitude to the colleagues who have cooperated in this research, including the managers and facilitating experts of the Soil and Watershed Protection Research Institute and Mazandaran University of Medical Sciences, and for their financial support and making the laboratory available.

Conflicts of Interest: "The authors declare no conflict of interest."

Data Availability Statement: Data is available on request from the corresponding author.

References

1. Azadbakht, M., Davoodi, A., Hosseinimehr, J., Emami, M., Azadbakht, M., 2021. Phytochemical Profiles, Physicochemical Analysis, and Biological Activity of Three *Colchicum* Species. Jundishapur J Nat Pharm Prod. 2021 May; 16(2):e98868. Published online 2021 April4.
2. Asgari, E., Talebi, A., Kiani-Harhegani, M., Amanian, N. 2024. The Effect of Vetiver Plant on Runoff Reduction and Soil Loss in Parallel-Convex and Concave Hillslopes in Laboratory Conditions. Iran-Watershed Management Science & Engineering. Vol. 17, No. 63, Winter 2024.
3. Alipour, N; Mahdavi, Kh; Mahmoudi, J.; Qalichnia, 1394 H. Investigating the effect of environmental conditions on the quantity and quality of *Stachys laxa* essential oil. Plant Research Journal (Iranian Biology Journal). Volume 28, Number 3.
4. Arianfar, M.; Akbari Nodehi, D.; Hemti, Kh; Rostampour, M. 2016. The effect of height and direction on the yield of essential oil and some phytochemical properties of medicinal species *Artemisia aucheri* Boiss and *Artemisia sieberi* Besser in South Khorasan pastures. Scientific and Research Journal of Marta - Year 12 - Number 3 Autumn 2017. 281-294.
5. Alipour, N.; Mahdavi, Kh; Mahmoudi, J.; Qalichnia, 2011 H. Investigating the effect of environmental conditions on the quantity and quality of *Stachys laxa* essential oil. Plant Research Journal (Iranian Biology Journal). Volume 28, Number 3.
6. Azarnivand, H., M. Ghavam Arabani., F. Sefidkon & A. Tavili, 2010. The effect of ecological characteristics on quality and quantity of the essential oils of *Achillea millefolium* L. subsp. *Millefolium* Iranian Journal of Medicinal and Aromatic Plants, 25(4): 556-571.
7. Asgari, E., Talebi, A., Kiani-Harhegani, M., Amanian, N. 2023. Comparison of the Effect of Vetiver Vegetation Cover and Surface Rock Fragment on Runoff and Soil loss in a Convex-Parallel Hillslope Under Laboratory Conditions. Eco HYDROLOGY. 10 (3), 335-353. Doi: doi. Org/10.22050/ije. 2023.361209.1741.

8. Bagharian Kalat, A; Lashkaripour, Gha; Ghafouri, M. 2021 Evaluation of the effects of watershed management measures on vegetation and the level of erosion and sedimentation in the Klakhak watershed. *Environmental Science and Technology*, Volume (23), Number (7), Year (2021-9), Pages (51-63).
9. Bahraini-Najad, B; Mirza, M. 2017. Investigating the effect of ecological factors on essential oil compositions of different genotypes of *Thymus daenensis* celak by using ranking technique. *Bimonthly scientific-research journal of medicinal and aromatic plants of Iran*. Volume 35. Number 2, page 196-208.
10. Ghavam Arabian, M., 2007. Investigating the Effect of Some Ecological Attributes on Essential Oil of *Achilea millefolium*. M.Sc. Thesis of Rangeland Management, Tehran University. (In Persian)
11. Ghadampur, A. Sharifi, F; Bahrami, H. 1392. Investigating the effects of Vetiver root density in soil erosion control using in situ and laboratory direct cutting experiments. Thesis. Ministry of Science and Technology - Tarbiat Modares University - Faculty of Agriculture and Natural Resources. <https://www.virascience.com/thesis/690548/>.
12. Gholamhosseinzadeh, b. Nik-Najad, Y; Fallah Amoli, H.; Mehdiinia Afra, Vol. 2014. Investigating the effect of altitude on the quantity and composition of mountain thyme essential oil in Pleur region of Amel city (case study). *Agricultural researches on the edge of the desert*, volume 13, number 4.
13. Haghighi, S. 2019. Vetiver plant, the green line against erosion and a step in the economy (Massimo Mafi). *Mahtab Gharb, Kermanshah*, 259 p.
14. Haider, F., N. Kumar., S. Banerigee., A. Naqvi & G. Baggi, 2009. Effect of altitude on the essential oil constituents of *Artemisia roxbourghiana* Besser Var. *Purpurascens* (Jacq) Hook. *Journal of Essential oil Research*, 21 (4) 303-304.
15. Jones, DL., Hodge, A and Kuzyakov, Y. 2004. Plant and mycorrhizal regulation of rhizodeposition. *New Phytologist*, 163: 459-480.
16. Jahantighi, H; Moghaddam, M; Valizadeh, M. 2019. Investigation on some autecology characteristics of Rohida (*Tecomella undulate* (Roxb.) seem.) in Sistan and Balouchestan province. *Iranian Journal of Medicinal & Aromatic Plants* 35 (1): 98-108. (In Farsi).
17. Khatouni, N. Kolahi, M. 2021. Investigating the role and function of pastures in the field of water. *Journal of water and sustainable development*. The eighth year, number 2, 2021, pp. 91-104.
18. Khaleghi, S; Nusrati, K; Abbaspour, 2019. Estimation of soil erosion and sediment transport in the upstream of Badavar watershed of Lorestan using SWAT model. *Quantitative geomorphology researches*, period 9, number 3, December 2019, pp. 186-202.
19. Maffei, M., Codignola, A. and Fieschi, M. (1988) Photosynthetic Enzyme Activities in Lemongrass Cultivated in Temperate Climates. *Biochemical Systematics and Ecology*, 16, 263–264.
20. Mehrpour, M.; Kashfi, B; Moghadam, 2015. Investigating the phytochemical and antioxidant compounds of different organs of the medicinal plant *Ferula assafoetida* L. in two natural habitats of Semnan and Khorasan provinces. *Ecophytochemical journal of medicinal plants*, number 13, year 4, number 1, spring.

21. Nazarpour, M.; Yadgari, M. 1400. Ecophytochemical investigation of essential oils of three types of medicinal plants. *Artemisia L* affected by climate and different phenological stages in Khuzestan province. *Ecophytochemical Journal of Medicinal Plants*, serial number 34. 9th year, number 2. summer.
22. Prophetic, J; Zali, H; Qurbani, C; Kazemi, 2014. Evaluation of the physical and chemical properties of soil and their relationship with the essential oil of pine cones (*Juniperus communis*) in Hazarjarib summer pastures of Mazandaran province. (*Iranian Journal of Biology*) (Scientific), 29(3), 608-618.
23. Panbehkar, F; Mokhtari, B; Rostgarzadeh, S.; Kolahi, M. 2017. Investigation of phytochemistry, measurement of phenolic compounds and antioxidant capacity of vetiver root extract (*Chrysopogon Zizanioides*). *Developmental biology quarterly (scientific-research)* - 10th year - number 4, autumn.
24. Raeisi Monfared, A; Yavari, A; Moradi, N. 2022. Investigation of ecological characteristics and its effect on essential oil yield of some *Salvia santolinifolia* Boiss. ecotypes in Hormozgan province. *Journal of Advanced Researches in Medicinal Plants* 1 (1): 11-24. (In Farsi).
25. Saufi, A. 2007. Lignans in (*Phaleria macrocarpa* Scheff.) Boerl. and in *Linum flavum* var. *compactum* L. Phd Thesis. Heinrich-Heine University, Düsseldorf, German, 95p.
26. Saleh, A.; Kavian, A.; Habib Nejad, 2018. Investigating plant phenological stages and types of pollutants in the effectiveness of plant buffer strips. *Watershed Science and Engineering Journal*. Spring 2018 number 44.
27. Sharifi, F.; Ghadampour, A.; Bahrami, 2013. Investigating the effects of vetiver root density in soil erosion control using in situ and laboratory direct cutting tests. Thesis. Ministry of Science and Technology - Tarbiat Modares University - Faculty of Agriculture and Natural Resources. <https://www.virascience.com/thesis/690548/>.
28. Taiz, L; Zeiger, E. 2006. *Plant Physiology*. Sinauer Assoc. Inc. Publ. Massachusetts. pp .35-348.
29. Truong, P.N.V. and Baker, D.E. (1998) *Vetiver Grass System for Environmental Protection*. Tech. Bull No 1998/1, Pacific Rim Vetiver Network (PRVN) Office of the Royal Projects Development Board (RDPB), Bangkok, Thailand.
30. Yavari, A; Nazeri, V; Sefidkon, F; Hassani, M.E. 2010. Influence of some environmental factors on the essential oil variability of *Thymus migricus*. *Natural Product Communications* 5 (6): 943-948.

Figures



(a)



(b)



(c)



(d)

Figure 1

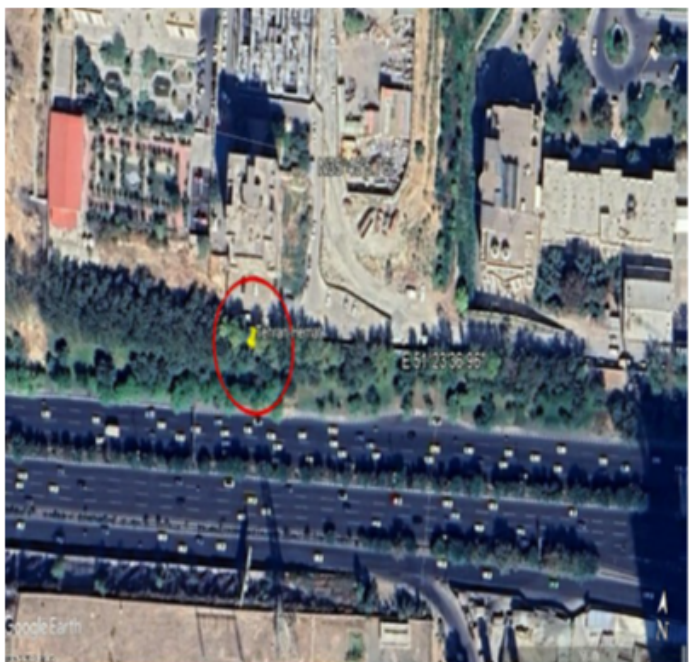
(A); (b); c) and (d) geographical location of the study area of Sangar dam reservoir - Gilan province



(a)



(b)



(c)



(d)

Figure 2

(a); (b); (c) and (d) Geographical location of the studied area, Hemmat highway - Tehran province.



(a)



(b)



(c)



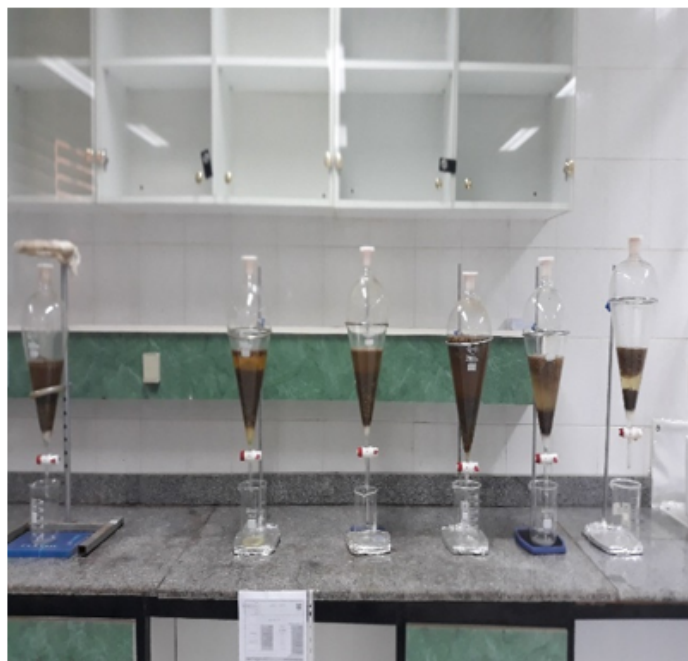
(d)

Figure 3

(a); (b); (c) and (d) Geographical location of the studied area of Narmab dam reservoir - Golestan province.



(a)



(b)



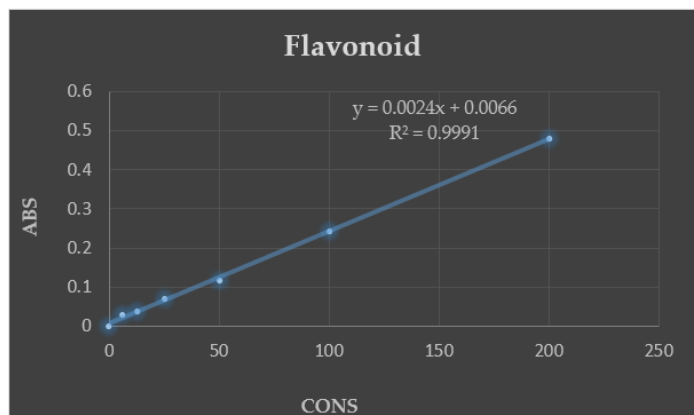
(c)



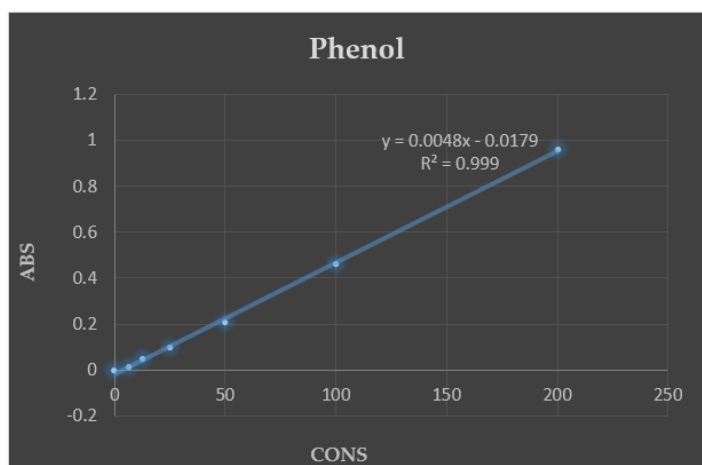
(d)

Figure 4

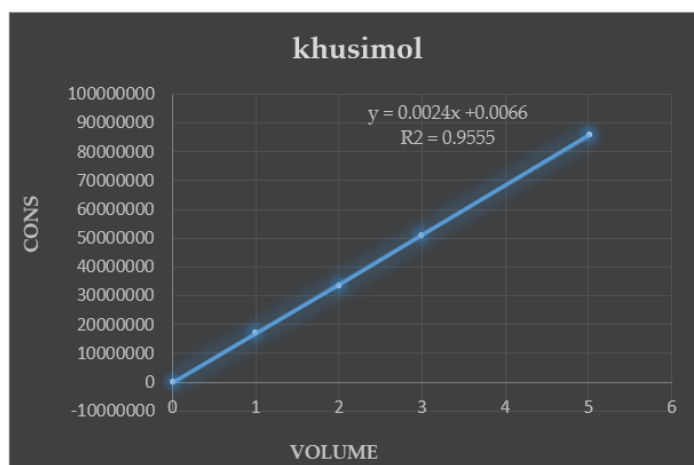
(a); (b); (c) and (d) Preparation steps of vetiver root extracts (*chrysopogon zizanioides*) - Pharmacognosy Laboratory, Faculty of Pharmacy, Mazandaran Medical Sciences.



(a)



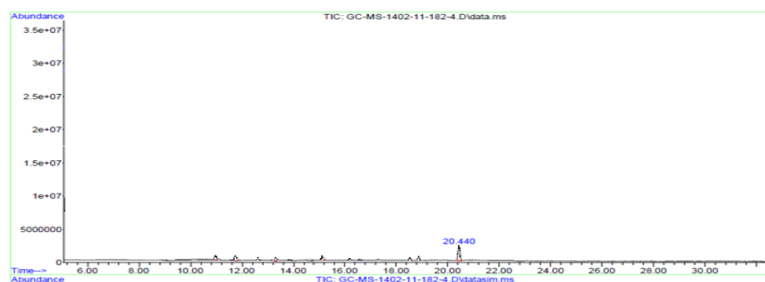
(b)



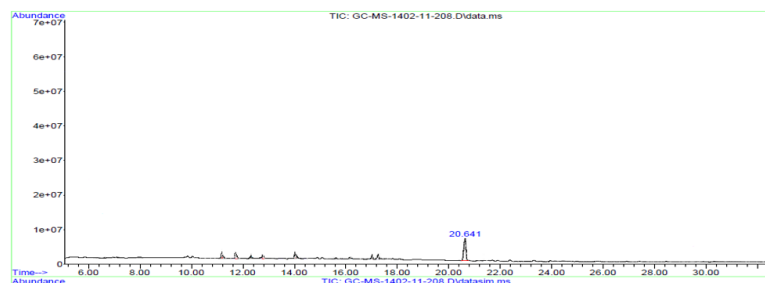
(c)

Figure 5

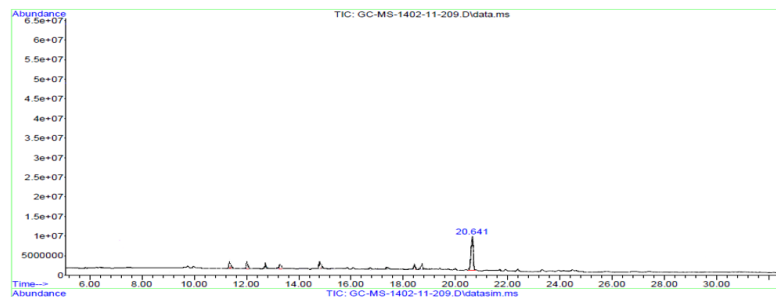
Figure 6. (a) The results of tests to determine the amount of total flavonoids in vetiver plant; (b) The results of experiments to determine the amount of total phenols in vetiver plant; (c) The results of experiments to determine the amount of Khusimol in Vetiver plant.



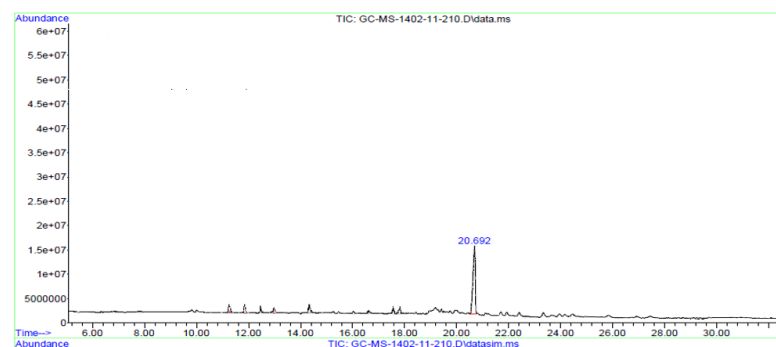
(a)



(b)



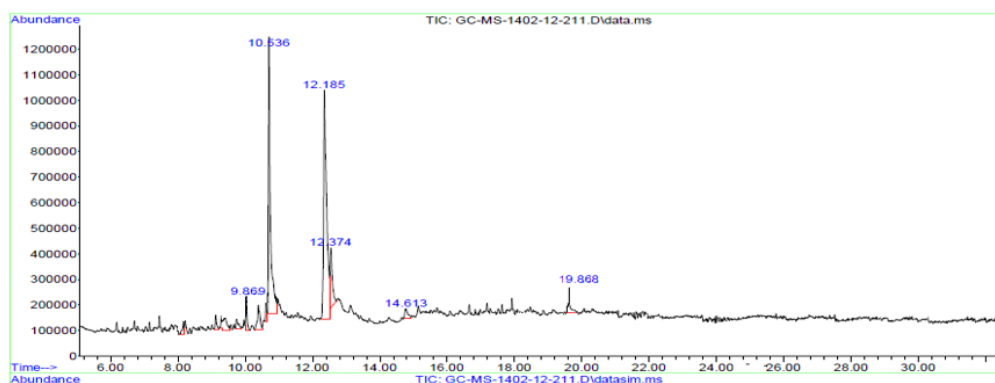
(c)



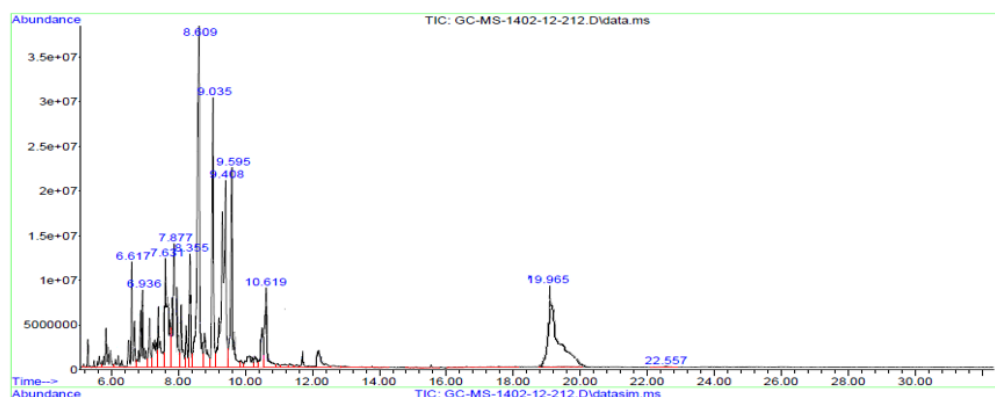
(d)

Figure 6

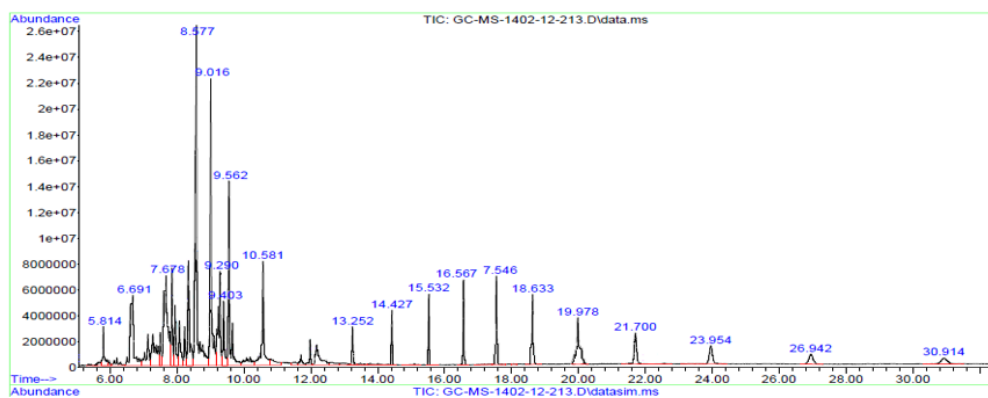
Figure 7. Calibration curve (a); chromatogram of Khusimol standard with concentration (1000 µg/ml)., (b); chromatogram of Khusimol standard with concentration (2000 µg/ml)., (c); chromatogram of Khusimol standard with concentration (3000 µg/ml), (d); chromatogram of Khusimol with concentration (5000 µg/ml).



(a)



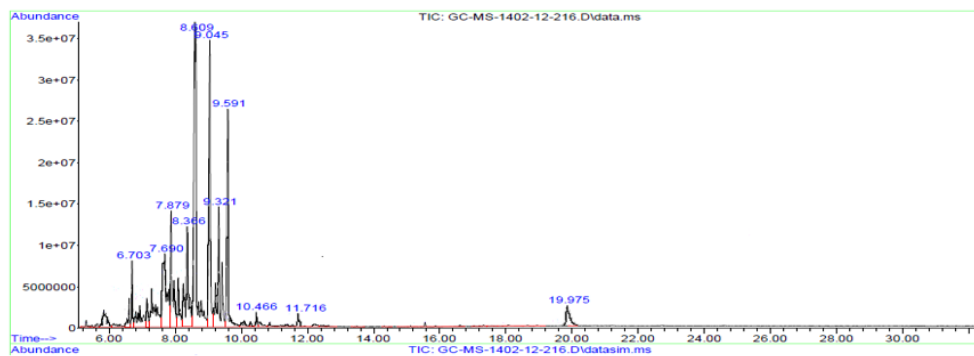
(b)



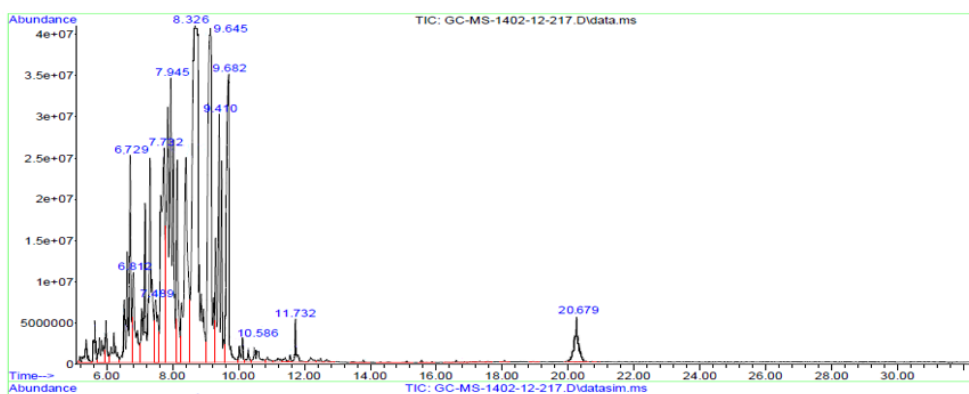
(c)

Figure 7

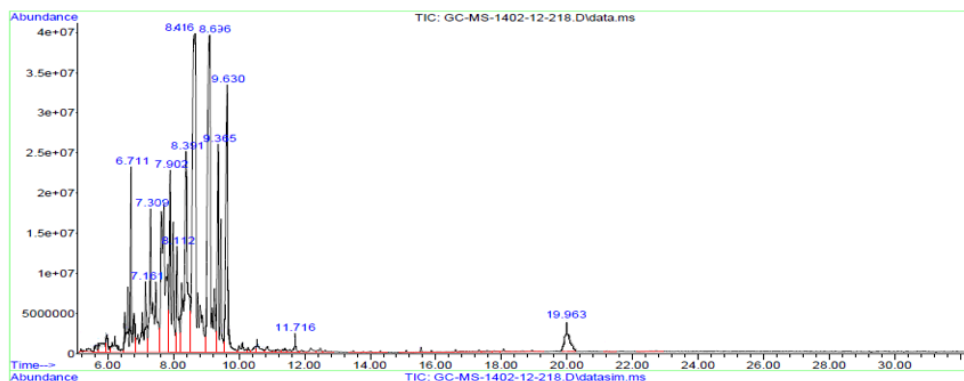
Figure 8. (a); GC chromatogram of vetiver root essence (sample from the first level with a slope of 30-40 degrees on the side slopes of Sangar-Gilan Dam)., (b); GC chromatogram of vetiver root essential oil (sample from the second level with 40-50 degree slope on the side slopes of Sangar-Gilan dam)., (c); GC chromatogram of vetiver root essence (sample from the third level with a slope of 60-70 degrees on the side slopes of the Sangar-Gilan dam).



(a)



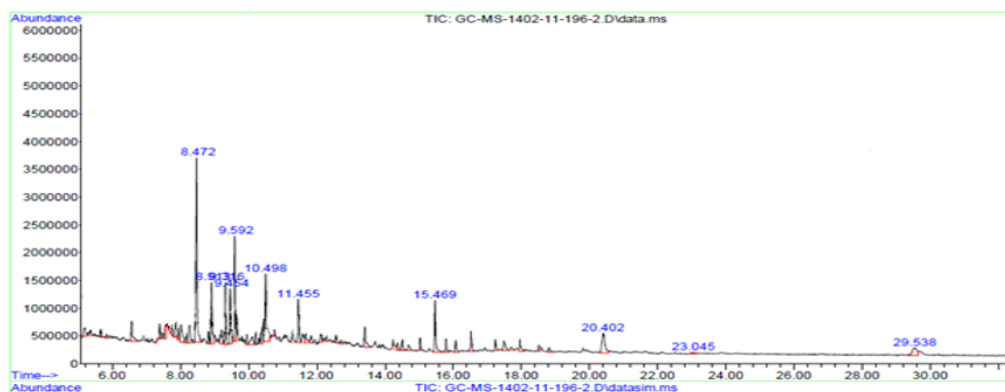
(b)



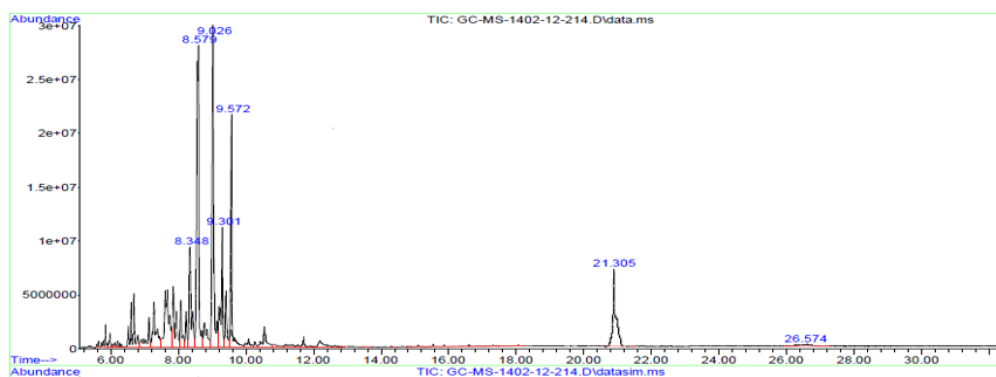
(c)

Figure 8

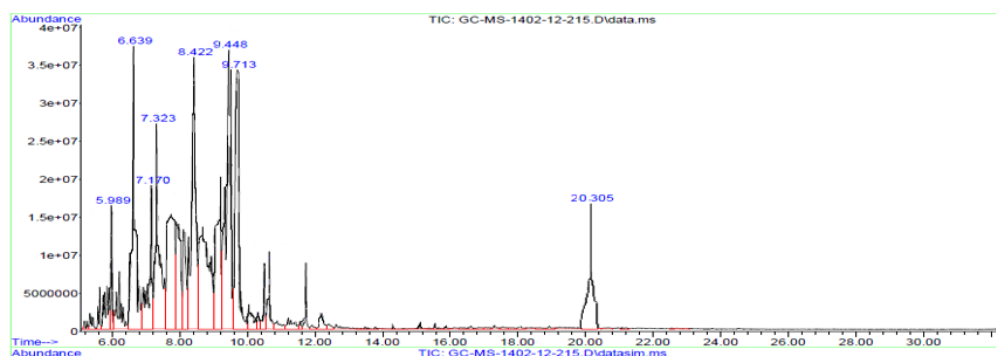
Figure 9. (a) GC chromatogram of vetiver root essential oil (sample from the first level with a slope of 40-50 degrees on the slope of Hemmat-Tehran highway)., (b); GC chromatogram of vetiver root essential oil (sample from the second level with a slope of 60-70 degrees on the side slope of Hemet-Tehran highway)., (c); GC chromatogram of vetiver root essential oil (sample from the third level with a slope of 80-90 degrees on the slope of Hemmat-Tehran highway).



(a)



(b)



(c)

Figure 9

Figure 10. (a) GC chromatogram of vetiver root essential oil (sample from the first level with a slope of 60-70 degrees on the side slope of Narmab-Golestan dam)., (b); GC chromatogram of vetiver root essence (sample from the second level with a slope of 70-80 degrees on the side slope of Narmab-Golestan dam)., (c); GC chromatogram of vetiver root essence (sample from the third level with a slope of 80-90 degrees on the side slope of Narmab-Golestan dam).

