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The Study of Anatomical Changes under the Influence of Cesium Uptake in *Chenopodium album* L.

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ABSTRACT

Lamb's quarters goosefoot (with scientific name "Chenopodium album L.") can absorb and purify heavy metals from environment. Cesium is one of pollutant and basic elements. Due to similarity to potassium, it can be absorbed by plants intensively. According to its absorption from the environment, cesium effect on anatomical and ontogenical structure of plant was studied. For this purpose, plant seeds were cultivated by hydroponic method with Hoagland solution and after two months, seedlings were incubated in the cesium chloride solution. Three studying groups were including a- control (irrigating by water) and treatment groups (irrigating by Cesium Chloride2 and 5 mg l^{-1}). Investigations on plants showed that cesium accumulates in their aerial organs. Because of this reason, these organs (aerial organs) were investigated for modifications studies. Observation showed that tissue structures of these organs had not changed at all and only xylems are expanded due to fight against tension and cells store cesium in their vacuole in crystalline shape for fighting against toxic effects of cesium. Increasing cesium concentration causes increasing in xylem and crystalline that will increase absorption of cesium and increases reaction against toxic effects of it. Regarding to the increase of cesium absorption from environment by expanding in xylem systems, this plant can be a potential candidate for phytoremediation of cesium, moreover no damage was observed on plant's tissue due to composing crystalline, so this plant can be introduced as a sufficient and suitable premeditator for removing toxins caused by cesium effects.

Key words: Remediation, *Chenopodium album*, Cesium, Anatomical Changes.

INTRODUCTION

Chenopodium L. belongs to Chenopodiaceae family. Diversity of this species has such varieties that their recognition is almost difficult. The plant with scientific name "*C. album* L." and

Persian name “SALMAK”, is an annual plant with stagnant stem and plenty ramifications which almost has pink and purple lines. Its height changing depends on water, weather and soil type. At the begging of growth, it rises from soil perpendicularly and achieving to 3 to 150 cm height. After sprout and growth (blossoming), plant turns to embowed shape due to seed and bud flower weight.

Chenopodium album can be cultivated in farms with other plants competitively and causes reduction on productions. In some area, Lamb’s quarters goosefoot has an edible usage too. Youth stem or whole plant can be fed after steaming. It is recommended to consume it cautiously regarding to excessive reserve of oxalic acid in this plant.

This plant is seen in most area of Iran such as northern and central part, south eastern, Semnan, Cheshmeh Ali Damghan, Saveh and Arak central plain [1].

Cesium (Latin phrase “Caesius”), means Skye blue, was discovered by Robber Bunsen and Gustav Kirchhoff in mineral water (Durkheim) in shape of experimental spectrum. Its identity is based on light bluish line in spectrum and it was the first element which was discovered by spectral analysis. The first cesium metal was produced in 1881. Respecting to historical aspect, the most important utilizations of cesium is applied in research and development project and fundamentally this metal has great chemical and electrical applications.

Basic metal is naturally occurred in igneous and sedimentary cliffs with concentration about 3 mg kg^{-1}. Furthermore this metal is occurred in soil with concentration range about 0 to 26 mg kg^{-1}. Cesium does not have any recognized nutrient roles on plants. In cultivated solutions with concentration more that 200 µM is toxic for plants. Cesium exists as a sustainable isotope [^{133}Cs in soil [2]. Cesium’s natural concentrations have not any importance for plants. Cesium movement in ecosystem and its distribution in plant and soil have been studied since 1950s. Moreover, it has showed more attraction due to developing nucleus technologies which are applied in producing energy. Cesium 137 has the most serious consequences effect on health, social pressures and economic issues [3].

^{137}Cs and ^{90}Sr are among radioactivity’s factors that cause maximum atomic hazards for aqueous reservoirs. Although other radioactive elements and their radio isotopes including zirconium, Ruthenium, Cerium and etc belong to pollutant factors, their quantity is less than their source and major original fountain [4].

Phytoremediation is the technique to segregate ^{137}Cs from environment. Plant roots, penetrating through buried position of radioactive wastes, transmit radio activated cesium to shallow part of soil through transpiration system. Finally, this process leads to purge the environment from this toxic element by absorbing them and accumulating it in plant’s tissue.

In this paper, *Chenopodium album* has been studied after hydroponic cultivation for surveying of cesium absorption ability, it’s reservoir in various organs and anatomical changes.

MATERIALS AND METHODS

Hydroponic cultivating

Hydroponic cultivating system is the soilless cultivated systems. Providing nutrition for plant is done by nutrition solutions in this method. In current research, Hoagland solution was produced base on Hoagland protocol 1950. Separated solutions are produced from macro elements and then appended to 240 L water as major tank. But micro elements are produced in solution with 240 ml liter volume. In hydroponic system, by means of avoiding light effect on physiologic performance of roots, Hoagland solution is entered to 10 liter container with dark colored curtain or containers which cover by dark textile or plastic and they were aerated with air pump through 5 mm pipe. In fact, cap of these containers are coating membrane which seeds budding on them and passing other phase of growth.

Cesium absorption and accumulation

In this section, plants were left from hydroponic growth system and washed by distilled water. Then they were being lied in cesium chloride solution [25ºC and pH: 6] with two concentration tested (2 and 5 milligrams per liter). Cesium concentration in solutions had been measured after finishing absorbing phase in Iranian Atomic Energy Organization with atomic absorption instruments. *Chenopodium album* species were still alive after two weeks in cesium chloride solution.

Experiments for accumulating cesium in plant's tissue

At the end of each experiment, plants were exited from cesium solution and washed by distilled water. Then plants were divided to two part [root and aerial parts] and being dried for 48 hours in oven at the 60ºC. Dry textures of plant were digested by the ration of 5:1 for HNO_3: $HClO_4$ respectively and cesium concentration were estimated by atomic absorption instrument.

Anatomical studies

After separation, Aerial organs of plant including stem and leaf had been laid in alcohol and glycerin for fixation at the same portion. After a week, a handy section was prepared and colored with multiple coloration [Carmen Zuji and methylene blue with ratio 1: 10]. Then samples were photographed and studied by Nikon microscope.

RESULTS

Absorption and accumulation of cesium

In this section, plants were left from hydroponic growth system and washed by distilled water. After studying various part of plant with atomic absorption instrument, it was specified that cesium only accumulates on aerial parts of plant which its quantity was estimated at 966.66± 84.29 mg kg^{-1} by the instrument, whereas absorbed cesium were not seen in other organs of plant at all.

Anatomical studies

Primary structure of stem in control plants

Based on previous studies on *Chenopodium album*, stem is covered by a cortical epidermis layer. Hypoderm includes several rows of collenchymas cells. Collenchyma is discontinuous and has 8

to 10 layers. Distance between membrane and Parenchyma is specified by endoderm and has Sclerenchyma texture sparsely. Parenchyma texture cells have oxalate crystals of macle type. Vain groups were sorted in one ring at the center. Regions in each vain group which specified from inside to outside, are including phloem region, pro cambium area and xylem vain region [figure 1]. Activity of cambium is definite which result in composing cambium rings which are responsible for composing secondary vain texture.

Secondary structure of stem in control plants

Study on secondary structure of this specimen showed that the quantity of collenchyma layer have increased under epidermis, moreover the fibers which locating on phloem have increases either [figure 2]. Interior cambium gathers together and composes a cambium ring with primary vain groups. This ring unnaturally cuts fiber ligaments at the cambium region [figure 3]. Quantity of macle crystals is increasing by producing of secondary structure [figure 4].

Structure of control's leaf

Leaves have extensive and thin epidermis. Fuzzes are multi cells and bubble shape, moreover they aren't divergence. Mesophyll has two rows of ladder parenchyma and several rows of spongy parenchyma. Makley crystals are seen in spongy parenchyma cells [figure 5]. Stomata are anisocytic type [figure 6].

Anatomical structure of aerial organs in treatment with cesium

By comparing aerial organs of plant under treatment by controlled plant with same ages, it was specified that cesium absorption by the plant and accumulation of this element in aerial organs (leaf and stem) makes some changes in mentioned organs which is more intensive by increasing cesium concentration.

Available observed changes due to absorb and accumulate of cesium can be classified to three groups:

1- Increase of crystals quantity in stem parenchyma and their color embrace [figures 8, 9 (a)].
2- Density of xylem vein groups and decrease of their dimension in stem [figures 8, 9 (b)].
3- Increasing color embrace property of xylem component in stem [figure 8, 9].
4- Decreasing cutaneous parenchyma in plants under treatment [figures 8, 9].
5- Increasing crystalline density and colored embrace in leaf's parenchyma [figures 10, 11].

There was not seen any other changes in the structure of studied organs.

CONCLUSION

Important point in phytoremediation is that the plants can be able to survive in polluted environment [5]. Another important point (as applied method for filtrating sewage), is that they must have high performance in refining sewage, beside they not only absorb pollutants, but also show less toxic effects during process [5 & 6]. Plant would be observed as a suitable tool for filtration and environmental management if pollutant concentration in soil and water becomes less than phytotoxic level [7]. Some weeds were chosen to apply for phytoremediation techniques out of their Rooty system [8]. *Chenopodium album* is one of these plants. Cesium has chemical activities as similar as potassium. Although there is not seen any nutritional role for cesium in plants, but large amount of this element can be so toxic for plants. Physiologic studies

revealed that because of similar entrance mechanism of cesium and potassium to plant, these two element compete with each other login to plant's organs. Ionic transmission through membrane has been focused in recent years [9]. Ionic channels are activated ways for transmitting charged ion through cell's membrane [2]. Most of channels are permeable toward other cations such as sodium, lithium, rubidium and cesium. Sizes of these cations are between 0.13 to 0.19 nm which is very similar to potassium's dimension (0.27 nm) and this fact causes their transmission through these channels [3 & 10].

Respecting these facts, cesium absorption by *Chenopodium album* might be related to its molecule's similarity to potassium. Therefore, performances of potassium channels are effective on cesium absorption [3].

In the experiments are done on algae revealed that cesium is accumulated in plant's cell after absorbing by plant as crystals. Concerting cesium to crystals in algae is a very attractive phenomenon. Cesium is seen as a soluble element in water in algae. This element can be replaced by other first group cations (I) of periodic table and then compose salt with anions [9 & 11].

Cooperating cesium in crystal's structure and its accumulation in vacuoles permit plant to absorb more content of radio activated cesium from environment without any serious incurred damage to plant [9]. Reducing diameter of vein's spout is a consequence of increasing xylem stiffness rate; demonstrates plant's adaption to tension terms and avoiding water wasting. So, water traverses more rapidly through veins by increasing of diameter of xylem wall's width and decreasing of vein's spout diameter [9]. It is concluded that expanding subsequent structure is a typical plant's defense against tension and inappropriate conditions of the environment. In Shahbazi *et al*'s report, color effecting (receipting) of xylem parts are more intensive than control plant which may be due to polymerization enhancing of units which forms xylem [12 & 13].

Considering increasing crystals numbers which are formed in the aerial organs of *Chenopodium album* and not seeing any damages in these organs and related tissue, it can be concluded that this plant causes to increase absorbed element from environment by enhancing its xylem system. Furthermore this plant fights against destructive effects of cesium by entering this element to crystalline structure. Totally by mentioned process, this plant enhancing its ability to absorb cesium from environment.

Regarding to these occasions;

1- Increasing absorbed amount of cesium due to enhancing xylem tissue
2- Not observing any damage to plant's tissue which caused by cesium content because of crystal composing

This plant, *Chenopodium album*, can be introduced as an appropriate purifying tool (phytoremediator) for removing toxic effects of cesium in environment.

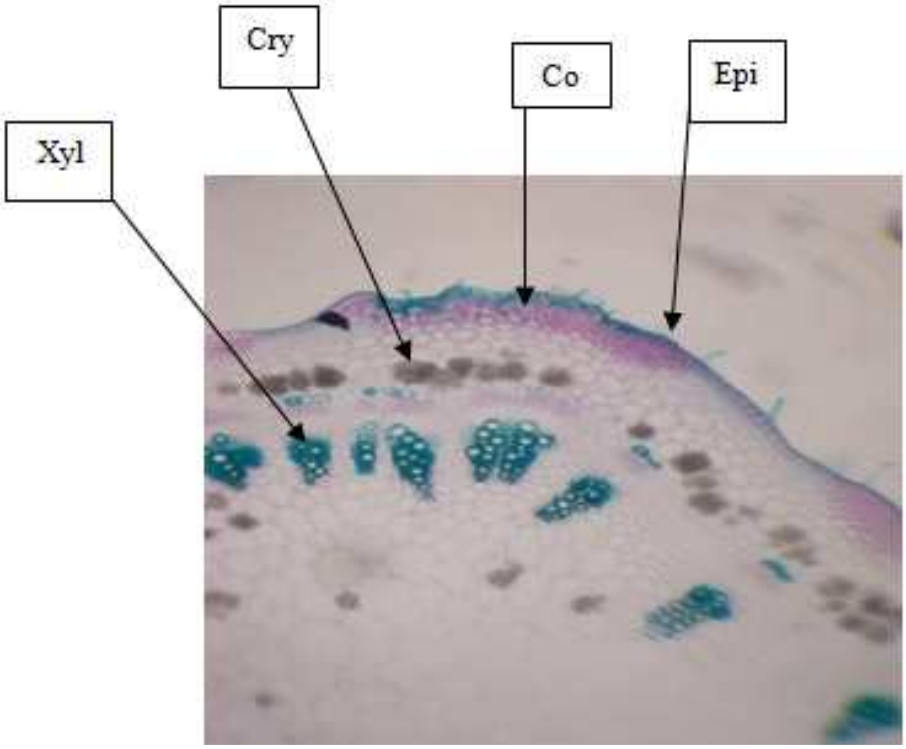

Figure 1- Primary structure of stem (Control) [x20]

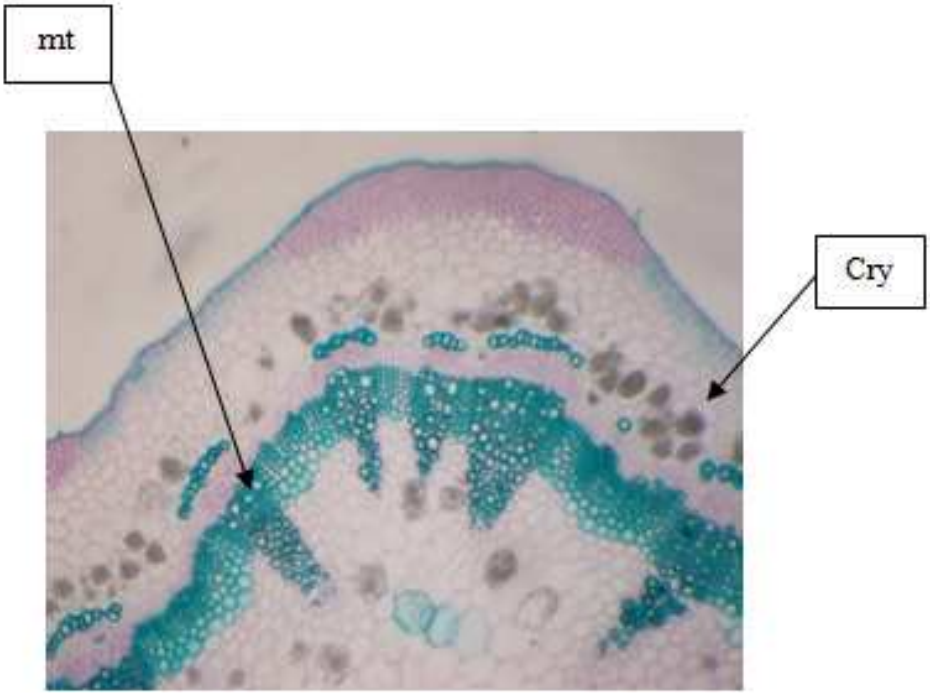

Figure 2- Secondary structure of stem (Control) [x20]

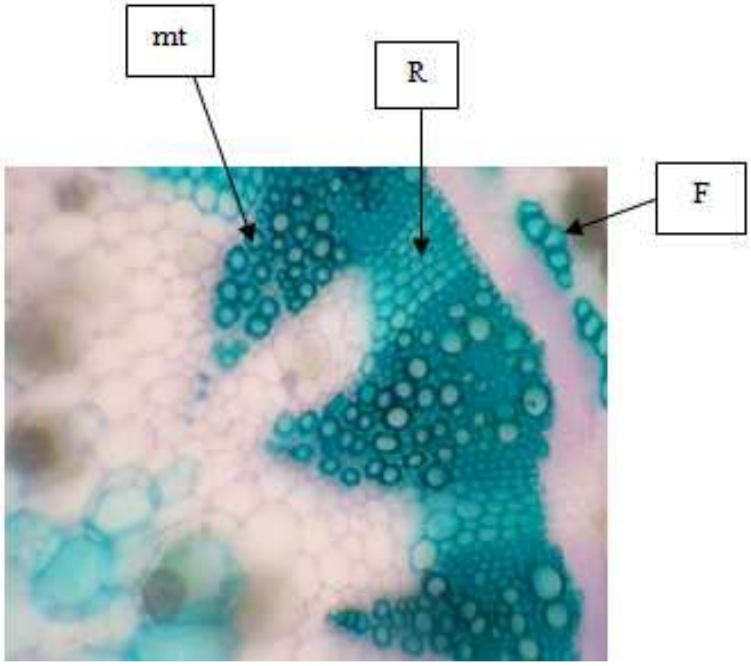

Figure 3- Secondary xylem [x40]

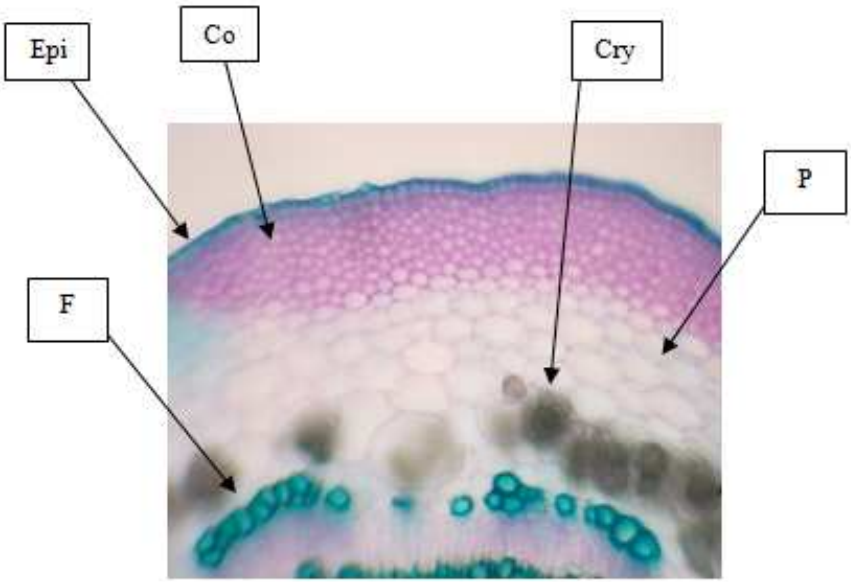

Figure 4- Increasing crystals quantity by composing secondary structure [x40]
Abbreviations: P=-Parenchyma; Xyl= Xylem, R=Ray , Phl= Phloem, mt = Meta xylem, F= Fiber, Epi=Epidermis; Co= Collenchyma , Cry= Crystal

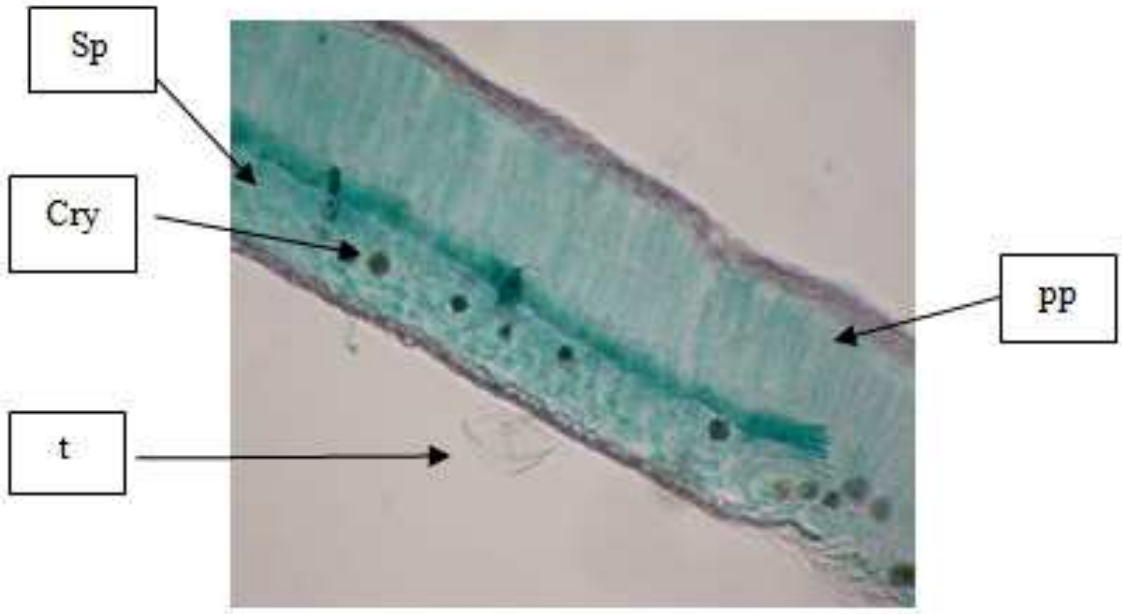

Figure5- Leaf Cross Section (Control) [x20]

Abbreviations: Cry= crystal, pp= ladder parenchyma, Sp= spongy parenchyma, t= fuzz

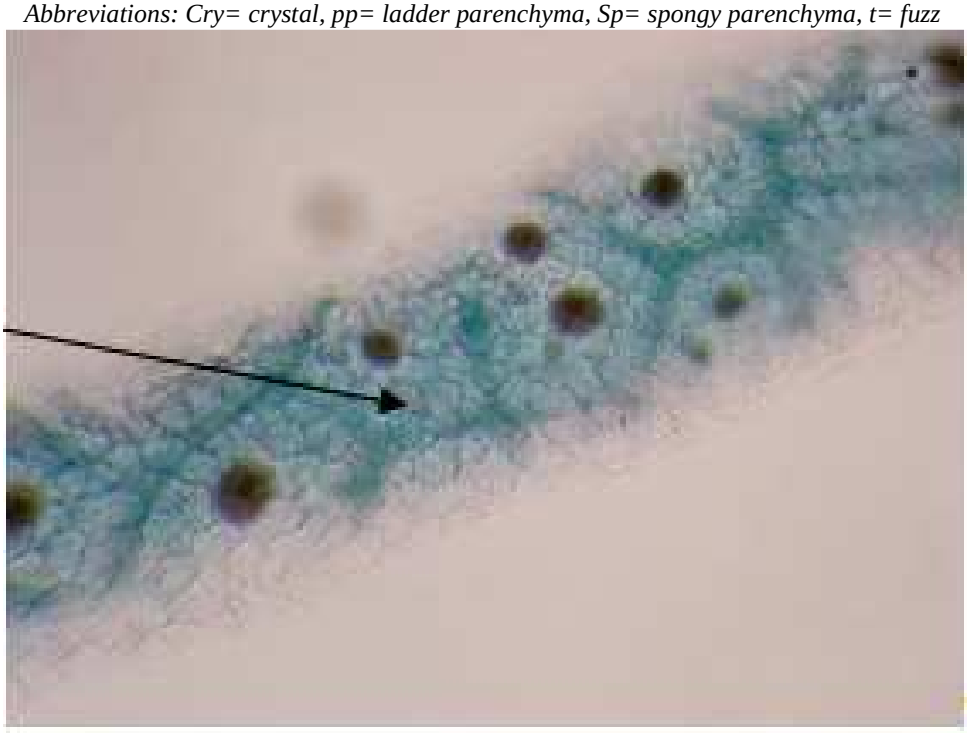

Figure 6- Anisocytic type of Stomata[x20]

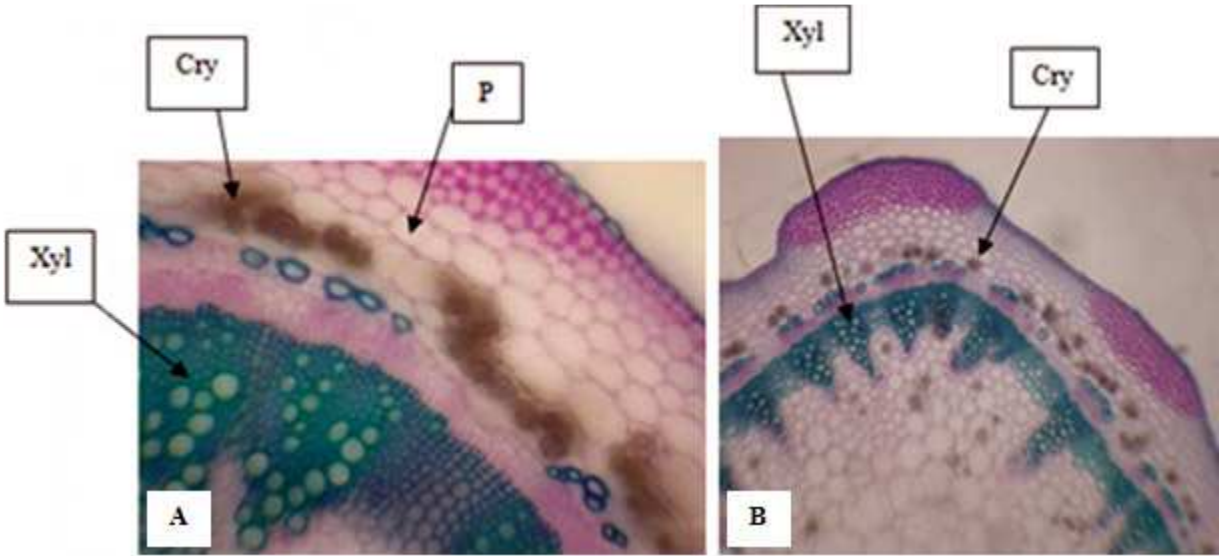

Figure 7- Stem- treated by cesium [2 ppm] (A= x20; B= x10)
Abbreviations: Cry= Crystal; P=- Parenchyma; Xyl= Xylem

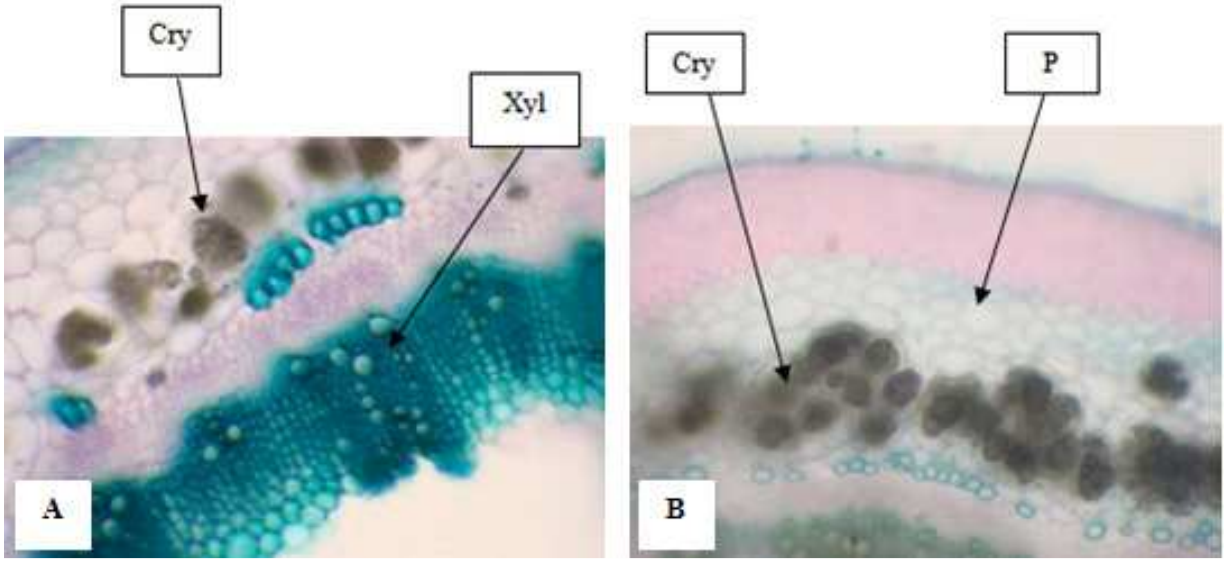

Figure 8- Stem- treated by cesium [5 ppm] (A= x20; B= x40)
Abbreviations: Cry= crystal; P=- paranchyma; Xyl= xylem

Figure 9- Leaf Cross Section- treated by cesium [2 ppm] (x20)

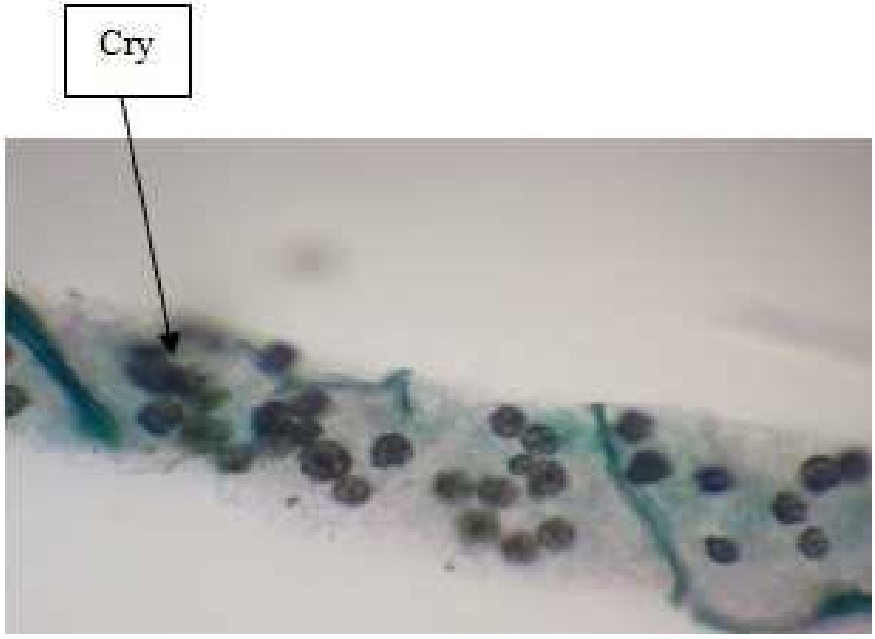

Figure 10- Leaf Cross Section - treated by cesium [5 ppm] (x20)
Abbreviations: Cry= Crystal

REFERENCES

[1] M Assadi. Iranical flore, forest and grassland researches Institute Publication, **2001**, Vol. 38.
[2] L L Cook; R S Inouye; T P McGonigle; G J White. *Journal of Arid Environments*. **2007**, 69: 40–64.

[3] S Singh; S Eapen; V Thorat; C P Kaushik; K Raj; S F D'Souza. *Ecotoxicology and Environmental Safety*, **2008**, 69: 306–311.
[4] V Ghishavandi. Marine pollution from nuclear accidents in Norway Sea coasts, Research and Technology Centre of Malek Ashtar University, Iran, **2008.**
[5] E Magdalene Ogbo; A Ufuoma; O Gloria. *African Journal of Plant Science*, **2009,** Vol. 3 (5): 102-106.
[6] E Pivetz Bruce. Ground Water Issue, Phytoremediation of Contaminated Soil and Ground Water at Hazardous Waste Sites, **2001**, EPA/540/s-01/500.
[7] S Shraddha; C P K Vidya Thorat; R Kanwar; E Susan; S F D'Souza. *Journal of Hazardous Materials*, **2008**, doi.org/10.1016/j.jhazmat.2008.05.097 (ARTICLE IN PRESS).
[8] N Merkl; R Schultze-Kraft; C Infante.. *Bioremediation*, **2004,** J. 8: 177-184.
[9] W Aprill; R C SIMS. *Chemosphere*, **1990**, 20: 253-265.
[10] J A Entry; N A Vance; M A Hamilton; D Zabowsky; L S Watrud; D C Adrino. *Water, Air and Soil Pollution*, **1996**, 88: 167-176.
[11] S Dragovic; S Stangovic. *J. serb. chem. Soc*, **2002,** 67(8-9) s87-sql.
[12] E A Bacelar; D L Santos; C M Correiq. *Plant Sci*, **2006**, 170: sat -602.
[13] A Majd; P Jonobi; M Sainipoor. *Journal of Developmental Biology*, **2009**, Vol. l, 4: 11-24.