ble (32): Total calcium accumulation in Azolla biomass per vessel and the percentage rate of Ca increase or decrease as related to the starting sample content after seven days of growth period as affected by 2 ppm Cd, 40 ppm Pb or 50 and 100 ppb Hg in the presence of variable levels of Ca in in the growing media.

a/L.	mg Ca / vessel						mg. Ca increase or decrease as related to the starting sample					% increase or decrease of Ca as related to the starting sample				
	Control	Cd	Pb	Hg		Average	Control	Cd	Pb	Hg		Control	Cd	Pb	Hg	
		2 ppm	40 ppm	50 ppb	100 ppb			2 ppm	40 ppm	50 ppb	100 ppb		2 ppm	40 ppm	50 ppb	100 ppb
000	3.7	1.9	2.6	2.8	2.6	2.7	+ 0.2	- 1.6	- 0.9	- 0.7	- 0.9	+ 5.7	- 45.7	- 25.7	- 20.0	- 25.7
396	11.3	7.1	6.9	7.5	5.8	7.7	+ 7.8	+ 3.6	+ 3.4	+ 4.0	+ 2.3	+ 222.9	-102.9	+ 97.1	- 114.3	+ 65.7
792	10.7	8.8	7.4	7.9	7.0	8.4	+ 7.2	+ 5.3	+ 3.9	+ 4.4	+ 3.5	+ 205.7	+151.4	+ 111.4	- 125.7	+ 108.0
188	10.4	9.3	8.1	8.3	7.8	8.8	+ 6.9	+ 5.8	+ 4.6	+ 4.8	+ 4.3	+ 197.1	+165.7	+ 131.4	+ 137.1	+ 122.9
ge	9.0	6.8	6.3	6.6	5.8		+ 5.5	+ 3.3	+ 2.8	+ 3.1	+ 2.3	+ 157.9	+100.7	+ 93.6	+ 89.3	+ 65.7
ing sample		3.5														

through the breakdown of calcium absorption rate, as it was mentioned before that Ca have a protective effects against the toxicity of heavy metals (True,1914;Nicholes, 1963 and Chester,1965), and when calcium absorption is limited by the heavy metals itself, the greatest the toxicity of such heavy element is appeared.

c) Total calcium content per one frond :

It could be summarized the conclusion which may be resulted from the examination of Table (33) as follows:

1) The highest accumulation of calcium in the frond was gained when Azolla plants were subjected to the growing medium containing the normal level of Ca and free from any heavy metals.

2) Heavy metals depressed the content of Ca per one frond, thus the rate of Ca accumulation as related to the starting sample was allways negative. The highest depressive effect on the accumulation of Ca per one frond was clearly showed under the treatments with 40 ppm Pb and 100 ppb Hg.

ble (33): Total calcium content per one frond and its percentage increase or dercrease rate as related to the starting one after seven days of growth period as affected by 2 ppm Cd, 540 ppm Pb or 50 and 100 ppb Hg in the presence of variable levels of Ca in the growing media.

a/L.	ug Ca / one frond						µg Ca increase or decrease as related to the starting sample					% increase or decrease of Ca as related to the starting sample				
	Control	Cd	Pb	Hg		Average	Control	Cd	Pb	Hg		Control	Cd	Pb	Hg	
		2 ppm	40 ppm	50 ppb	100 ppb			2 ppm	40 ppm	50 ppb	100 ppb		2 ppm	40 ppm	50 ppb	100 ppb
.000	9.9	3.6	4.4	5.9	5.5	5.9	- 11.5	- 17.8	- 17.0	- 15.5	- 15.9	- 53.7	- 83.2	- 79.4	- 72.4	- 74.3
.396	35.2	14.4	14.9	17.8	13.6	19.2	+ 13.8	- 7.0	- 6.5	- 3.6	- 7.8	+ 64.5	- 32.7	- 30.4	- 16.8	- 36.4
.792	34.7	18.4	16.9	13.0	13.2	19.2	+ 13.3	- 3.0	- 4.5	- 8.4	- 8.2	+ 62.1	- 14.0	- 21.0	- 39.3	- 38.3
.188	34.5	19.8	15.0	17.1	17.8	20.8	+ 13.1	- 1.6	- 6.4	- 4.3	- 3.6	+ 61.2	- 7.5	- 29.9	- 20.1	- 16.8
age	28.6	14.1	12.8	13.5	12.5		+ 7.2	- 7.1	- 8.6	- 8.0	- 8.9	- 60.4	- 34.4	- 40.2	- 37.2	- 41.5
ting sample		21.4														

7) Magnesium contents :

Tables (34, 35 and 36) represents tha data of magnesium contents in terms of concantration, total amounts per vessel and per one frond respectively.

a) Magnesium concantrations :

It may be concluded from the concentration of magnesium in plant tissues that the highest amounts was gained when Ca was absent from the growing media and free from heavy metals. Such concentration was decreased with increasing the level of Ca. Thus, it may be concluded that the presence of Ca retarded the absorption of Mg, as it was suggested that Ca regulate the absorption of other ions .

It was suggested also that different heavy metals seemed to have a depressive effect on Mg concentration, and that explain partially their toxic effect on plant growth. Such depressive effect is regulated by the presence of Ca at different rates in the growing media.

b) Total magnesium content in Azolla biomass per vessel :

It could be revealed the following conclusions from the data of Table (35):

Table (34): Magnes ium concentration in Azolla plant tissues after seven days of growth period as affected by 2 ppm Cd, 40 ppm Pb or 50 and 100 ppb Hg in the presence of variable Ca levels in the growing media.

Mg.Ca/L.	mg Mg./ gr. dry matter					
	Control	Cd	Pb	Hg		Average
		2 ppm	40 ppm	50 ppb	100 ppb	
0.000	10.0	8.9	6.0	7.0	6.0	7.6
44.396	8.0	6.0	6.5	7.5	7.0	7.0
88.792	7.2	6.4	6.6	7.9	7.0	7.02
133.188	7.0	6.0	5.3	7.8	7.1	6.6
Average	8.1	6.8	6.1	7.6	7.8	
Starting sample		6.0				

ble (35): Total magnesium accumulation in Azolla biomass per vessel and its percentage increase or decrease rate as related to the starting sample conetnt after seven days of growth period as affected by 2 ppm Cd, 40 ppm Pb or 50 and 100 ppb Hg in the presence of variable Ca levels in the growing media.

Ca/L.	mg. Mg / vessel						mg. Mg increase or decrease as related to the starting sample					% increase or decrease of Mg as related to the starting sample				
	Control	Cd	Pb	Hg		Average	Control	Cd	Pb	Hg		Control	Cd	Pb	Hg	
		2 ppm	40 ppm	50 ppb	100 ppb			2 ppm	40 ppm	50 ppb	100 ppb		2 ppm	40 ppm	50 ppb	100 ppb
0.000	8.2	5.1	4.3	5.0	3.9	5.3	5.8	2.7	1.9	2.6	1.5	241.7	112.5	79.2	108.3	62.5
4.396	8.2	4.8	5.4	5.7	5.1	5.8	5.8	2.4	3.0	3.3	2.7	241.7	100.0	125.0	137.5	112.5
8.792	6.9	5.5	5.5	6.2	5.2	5.9	4.5	3.1	3.1	3.8	2.8	187.5	129.2	129.2	158.3	116.7
3.188	6.3	5.4	4.6	6.8	5.6	5.7	3.9	3.0	2.2	4.4	3.2	162.5	125.0	91.7	183.3	133.3
rage	7.4	5.2	5.0	5.9	5.0		5.0	2.8	2.6	3.5	2.6	208.4	116.7	106.3	146.9	106.3

rting sample 2.4

1) The highest absorption rate of Mg was occurred when Azolla biomass was subjected to the lower level of Ca or at the complete absence of such element, while the application of higher levels of Ca to the growing media reduced such absorption rate.

2) Different treatments with heavy metals depressed greatly the absorption rate of Mg and the most depressive effect was gained when Ca was absent from the growing media.

3) Pb or 100 ppb Hg had the highest depressive effect on the absorption rate of Mg.

c) Total magnesium content per one frond :

It could be revealed from data of Table (36) that the same trend could be noticed concenrning the total Mg per one frond as discussed gefore in the case of total Mg in the biomass per vessel. However, the accumulation rate per one frond was lower than that which found in the beginning sample and that related to the negative rate of accumulation. This result give more support to the various results which dealing with the concentration, the absorption and accumulation of different studied nutrient elements, as both heavy metals and the level of Ca affected such parameters.

ble (36): Total magnesium content per one frond and its percentage increase or decrease rates as related to the starting one after seven days of growth period as affected by 2ppm Cd,40 ppm Pb or 50 and 100 ppb Hg in the presence of variable lvels of Ca in the growing media.

Ca/L.	µg Mg / one frond						µg Mg increase or decrease as related to the starting sample					% increase or decrease of Mg as related to the starting sample				
	Control	Cd	Pb	Hg		Average	Control	Cd	Pb	Hg		Control	Cd	Pb	Hg	
		2 ppm	40 ppm	50 ppb	100 ppb			2 ppm	40 ppm	50 ppb	100 ppb		2 ppm	40 ppm	50 ppb	100 ppb
0.000	22.0	9.8	7.2	10.5	8.4	11.6	+ 7.6	- 4.6	- 7.2	- 3.9	- 6.0	+ 52.8	- 31.9	- 50.0	- 27.1	- 41.7
4.396	25.6	9.6	11.7	13.5	11.9	14.5	+ 11.2	- 4.8	- 2.7	- 0.9	- 2.5	+ 77.8	- 33.3	- 18.8	- 6.3	- 17.4
8.792	22.3	11.5	12.5	10.3	9.8	13.3	+ 7.9	- 2.9	- 1.9	- 4.1	- 4.6	+ 54.9	- 20.1	- 13.2	- 28.5	- 31.9
3.188	21.0	11.4	8.5	14.0	12.8	13.5	+ 6.6	- 3.0	- 5.9	- 0.4	- 1.6	+ 45.8	- 20.8	- 41.0	- 2.8	- 11.1
rage	22.7	10.6	10.0	12.1	10.7		+ 8.3	- 3.8	- 4.4	- 2.3	- 3.7	+ 57.8	- 26.5	- 30.8	- 16.2	- 25.5
rting sample		14.4														

It could be concluded that heavy metals exerted their toxic effect on plant growth through the retarding effects on the absorption and accumulation of different nutrient elements, beside their adverse effect on different plant metabolic processes.

8) Total amounts of macro-nutrients in Azolla biomass per vessel and their proportion percentage distribution as related to the total amounts :

The study of proportion distribution of macro-nutrients may provide us with some information about the mode of action of the present treatments.

It could be revealed the following conclusions from the data of Table (37,a,b,and c):

1) The highest amount of total accumulated macro-nutrients was gained when Ca was applied as 2/5 level of Hoagland solution. Omission of Ca or the higher rate of Ca over the normal level decreased such accumulation. These results agree with those obtained in growth parameters especially dry weight accumulation of biomass per vessel . Accordingly, we consider such treatment as the stander of proportion balance between different nutrient,elements to compare different treatments.

2) In this standard treatment more than three quarters

of macro-nutrients are found as N and K, while the other macro-nutrients nearly equal one quarter.

3) Plants which omitted from Ca possessed lower proportion of N,Ca and higher proportion of P,K and Mg comparing to the standard treatment. This lead to the assumption that the depressive effect of Ca absence on growth parameters may be resulted partially from the disturbance in the balance between the absorption of macro-nutrients; beside its essential role in plant metabolism .

4) Increasing the level of Ca over the standard one (44.396 mg .Ca/L.) seemed to disturbe the balance between the proportion accumulation within plant tissues and the absorption of macro-nutrients and that take a part in the depressive effect on plant growth.

5) All of the tested heavy metals depressed greatly the accumulation and the absorption of macro-nutrients. This lead to the desterbance in the proportion accumulation balance between the macro-nutrients in biomass tissues and that lead to the depressive effect on plant growth.

6) The presence of Ca at different levels in the media may regulate the mechanism of toxic effect of heavy

metals on the absorption and accumulation balance of macro-nutrients. However such regulation not reached the standard balance which observed by standard treatments and that lead to the depressive effect on growth.

7) The differences between the proportion of macro-nutrients which resulted from different treatments with heavy metals, may indicate that the mechanism of toxic action are completely different between the tested heavy metals, and that lead to the variable differences on plant growth.

8) The above mentioned results may provide us with the conclusion about the mode of action of heavy metals as toxic substances both plant growth and its chemical composition.

Table (37 a):Total amounts of macro-nutrients in Azolla biomass per vessel and their percentage distribution as related to the total amounts after seven days of culture period.

mg.Ca/L.	Control						Cd 2 ppm					
	Total amounts of macro nutrients mg/ vessel	percentage distribution					Total amounts of macro nutrients mg./ vessel	percentage distribution				
		N	P	K	Ca	Mg		N	P	K	VCa	Mg
0.000	89.1	37.1	8.8	40.7	4.2	9.2	48.1	40.1	6.9	38.5	4.0	10.6
44.396	123.2	38.1	7.6	38.4	9.2	6.7	73.5	37.4	7.1	39.3	9.7	6.5
88.792	115.9	38.5	7.1	39.3	9.2	6.0	84.3	36.7	8.9	37.5	10.4	6.5
133.188	102.9	37.2	7.2	39.4	10.1	6.1	84.7	35.9	8.0	38.7	11.0	6.4
Average	107.8	37.7	7.7	39.5	8.2	7.0	72.7	37.5	7.7	38.5	8.8	7.5
Starting sample	35.5	41.4	3.9	38.0	9.9	6.8						