

RESULTS

Various chromosomal aberrations were observed in the bone marrow of rats exposed to microwave and mobile phone radiation at different time intervals. The structural type of aberration was identified and quantified relative to non-exposed control of 42 chromosomes (Fig 2).

Chromosomal study:

Chromosomal aberrations could be classified into "numerical" and "structural" aberrations.

Structural aberrations:

Include chromatid deletion (Fig. 3), chromatid gap (Fig. 4), break (Fig. 5), ring (Fig. 6), end to end association (Fig. 7), centric fusion (Fig.8) and centromeric attenuation (Fig. 9).

The chromosomes appear sticky, often joined to one another by fine thread and tending to clump into a massive structure at division. Stickiness was a sort of chromosomal agglutination. It may give rise to sticky adhesions between two or more chromosomes or chromatids, associated and move to the opposite spindle poles. The sticky condition may be induced by application of a wide variety of chemical and physical agents during the condensed state of chromosomes in mitosis and meiosis as indicated in (Fig. 10).

The data obtained with the analysis of structural chromosome aberrations in bone marrow cells of rats after exposure to microwave or mobile radiation are presented in the following tables depending on the duration of exposure, and also the data of rats administrated daily with 0.1ml (20mg/ml) Tomex during the exposure to microwave and mobile phone radiation are followed.



Fig. (2): Normal bone marrow metaphase spread of *Rattus norvegicus*.

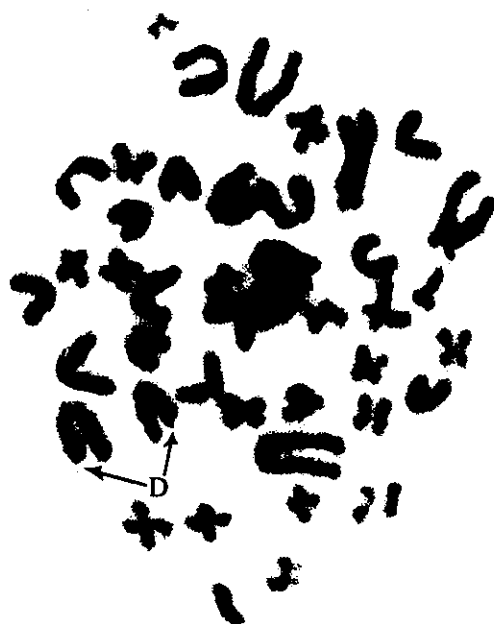


Fig. (3): Metaphase spread showing deletion (D) in bone marrow cells of rats exposed to microwave and mobile phone radiation.



Fig. (4): Metaphase spread showing chromosome gap (G) in bone marrow cells of rats exposed to microwave and mobile phone radiation.

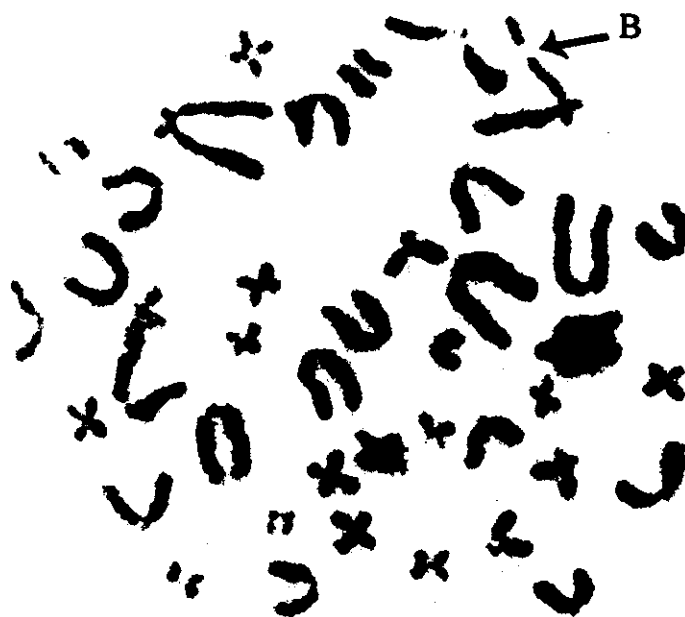


Fig. (5): Metaphase spread showing break (B) in bone marrow cells of rats exposed to microwave and mobile phone radiation.

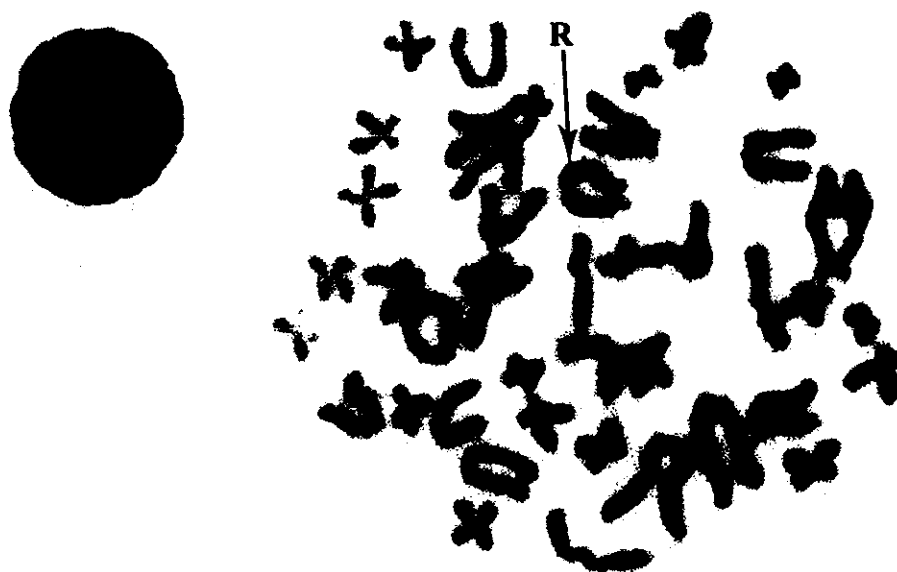


Fig. (6): Metaphase spread showing ring chromosome (R) in bone marrow cells of rats exposed to microwave and mobile phone radiation.

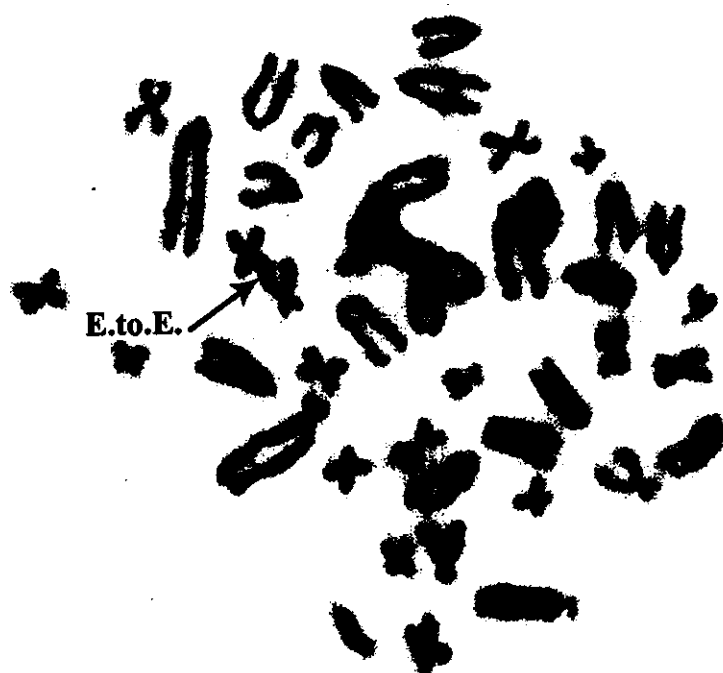


Fig. (7): Metaphase spread showing end to end association (E.E.) in bone marrow cells of rats exposed to microwave and mobile phone radiation.

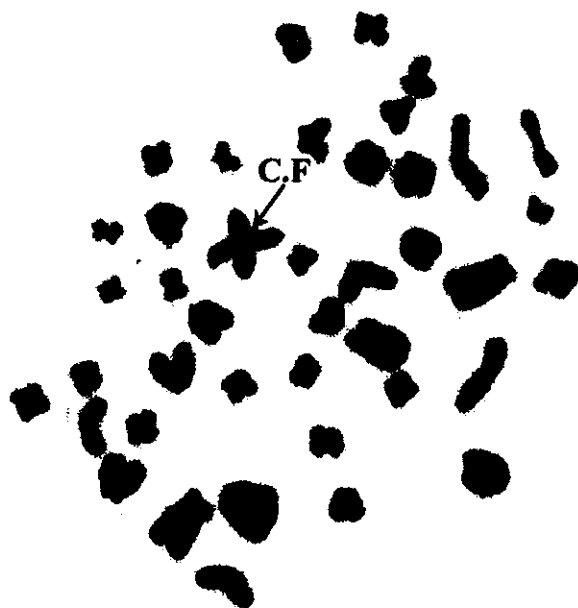


Fig. (8): Metaphase spread showing centric fusion (C.F.) in bone marrow cells of rats exposed to microwave and mobile phone radiation.



Fig. (9): Metaphase spread showing centromeric attenuation (C.A.) in bone marrow cells of rats exposed to microwave and mobile phone radiation.



Fig. (10): Metaphase spread showing sticky (S) in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Chromatid type aberrations:

In the present study, Table (1), Fig. (11a, b), shows the mean values of chromatid deletion in bone marrow cells of rats exposed to microwave and mobile phone radiation. There was an increase in the frequency of deletions in bone marrow cells of rats after exposure to microwave radiation with 9865 MHz for 30, 45 and 60 days and mobile phone radiation with 900 MHz for 14, 30 and 45 days comparing to the control group. The highest frequency ($P < 0.001$) was found after the 45 -days interval in the microwave exposed groups, while the (microwave & Tomex) groups were significant for the three periods of exposure (30, 45 and 60 days). For the mobile phone groups, it was highly significant ($P \leq 0.01$) after 30 days of exposure while in the (mobile phone & Tomex) groups it was significant only at 30 and 45 days of exposure. The mean values of aberrant cells which were found 19.80 ± 5.85 ; 24.80 ± 3.89 and 21.60 ± 5.94 in the microwave exposed animals at 30, 45, and 60 days, respectively, were reduced to 8.20 ± 2.59 , 14.60 ± 4.09 , 13.60 ± 3.05 in the (microwave & Tomex) groups respectively. These results were similar to the groups of animals exposed to mobile phone radiation as the mean value was decreased after 14 days from 20.00 ± 7.25 to 11.60 ± 3.58 but increased again at 30 days from 17.00 ± 3.16 to 19.80 ± 9.20 , then it decreased from 22.80 ± 10.47 to 13.80 ± 5.81 at 45 days in the (mobile & Tomex) groups. The recovery groups were decreased in most groups comparing to the exposed ones but remained higher than the control.

The data presented in (Table 2) (Fig. 12 a, b) showed no significant difference in the frequency of breaks comparing to the control in bone marrow cells of animals exposed to microwave and mobile phone radiation except at 60 and 45 days interval ($t=4.274$ & $P < 0.05$) and ($t=3.586$ & $P \leq 0.05$) respectively. By comparing the (microwave and microwave &

Results

tomex) groups and the (mobile phone and mobile phone & tomex) groups, it showed highly significant decrease of breaks ($t=4.960$ & $P 0.01$) and ($t=4.802$ & $P 0.01$) at 60 and 45 days respectively. By comparing the mean values of the recovery groups with the control, a significant decrease in all groups was observed.

Table (1): The mean values of deletion in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	5.00 $\pm$ 3.46			
Microwave	1) 30 days	19.80 $\pm$ 5.85	4.95**		
	2) 45 days	24.80 $\pm$ 3.89	11.96***		
	3) 60 days	21.60 $\pm$ 5.94	5.58**		0.000***
	4) R	12.00 $\pm$ 3.00	2.56*		
Microwave & Tomex	1) 30 days	8.20 $\pm$ 2.59	3.14*	3.59*	
	2) 45 days	14.60 $\pm$ 4.09	3.38*	3.87*	
	3) 60 days	13.60 $\pm$ 3.05	3.13*	3.09*	0.001***
	4) R	10.80 $\pm$ 1.92	3.27*	0.65	
Mobile phone	1) 14 days	20.00 $\pm$ 7.25	5.21**		
	2) 30 days	17.00 $\pm$ 3.16	5.48**		
	3) 45 days	22.80 $\pm$ 10.47	4.44**		0.004***
	4) R	13.20 $\pm$ 5.89	4.63**		
Mobile phone & Tomex	1) 14 days	11.60 $\pm$ 3.58	2.35	2.69*	
	2) 30 days	19.80 $\pm$ 9.20	3.06*	0.92	
	3) 45 days	13.80 $\pm$ 5.81	3.47*	1.92	0.010**
	4) R	10.80 $\pm$ 4.09	1.89	0.57	

* Significant ($P \leq 0.05$)

** Highly significant ($P \leq 0.01$)

*** Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig.(11a): Mean of deletion observed in bone marrow cells of rats exposed to microwave radiation

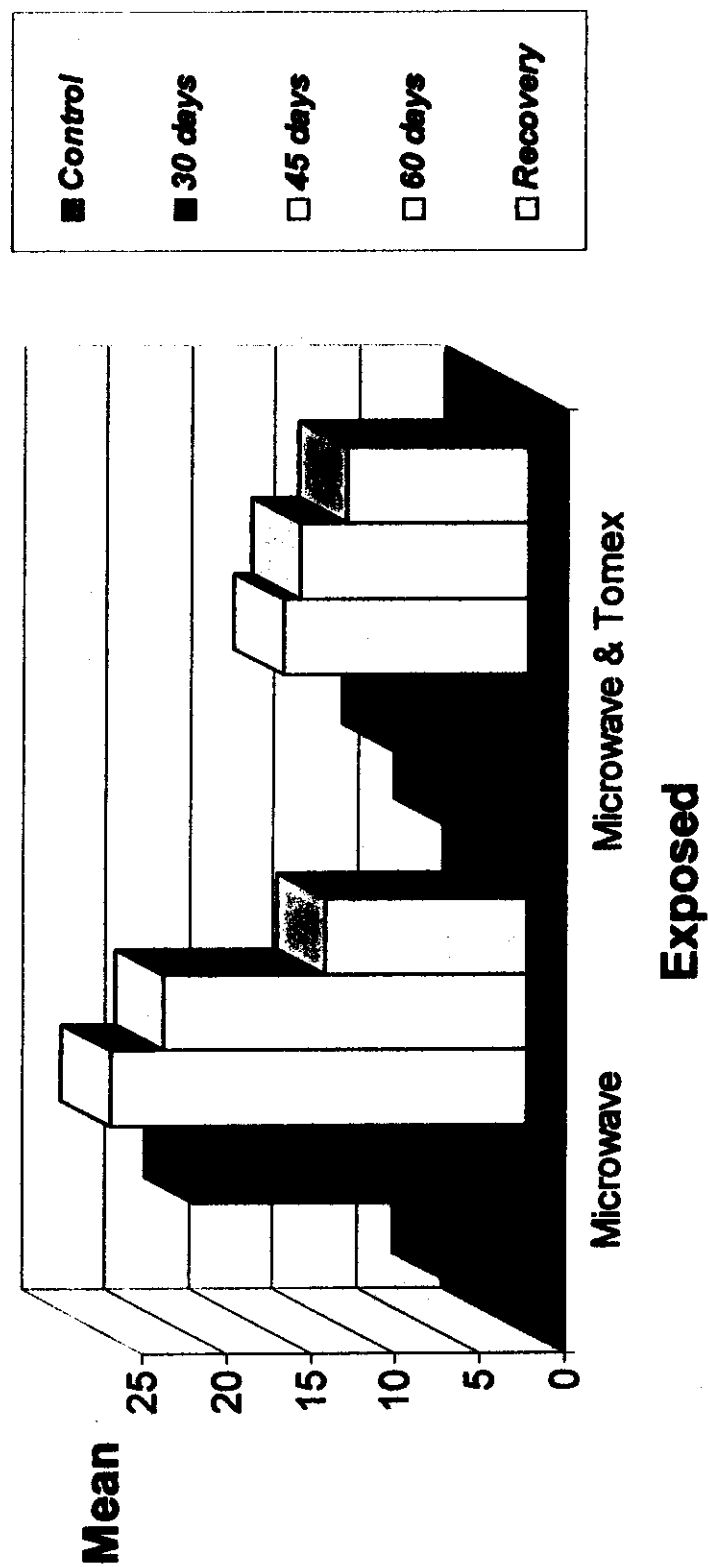


Fig.(11b): Mean of deletion in bone marrow cells of rats exposed to mobile phone radiation

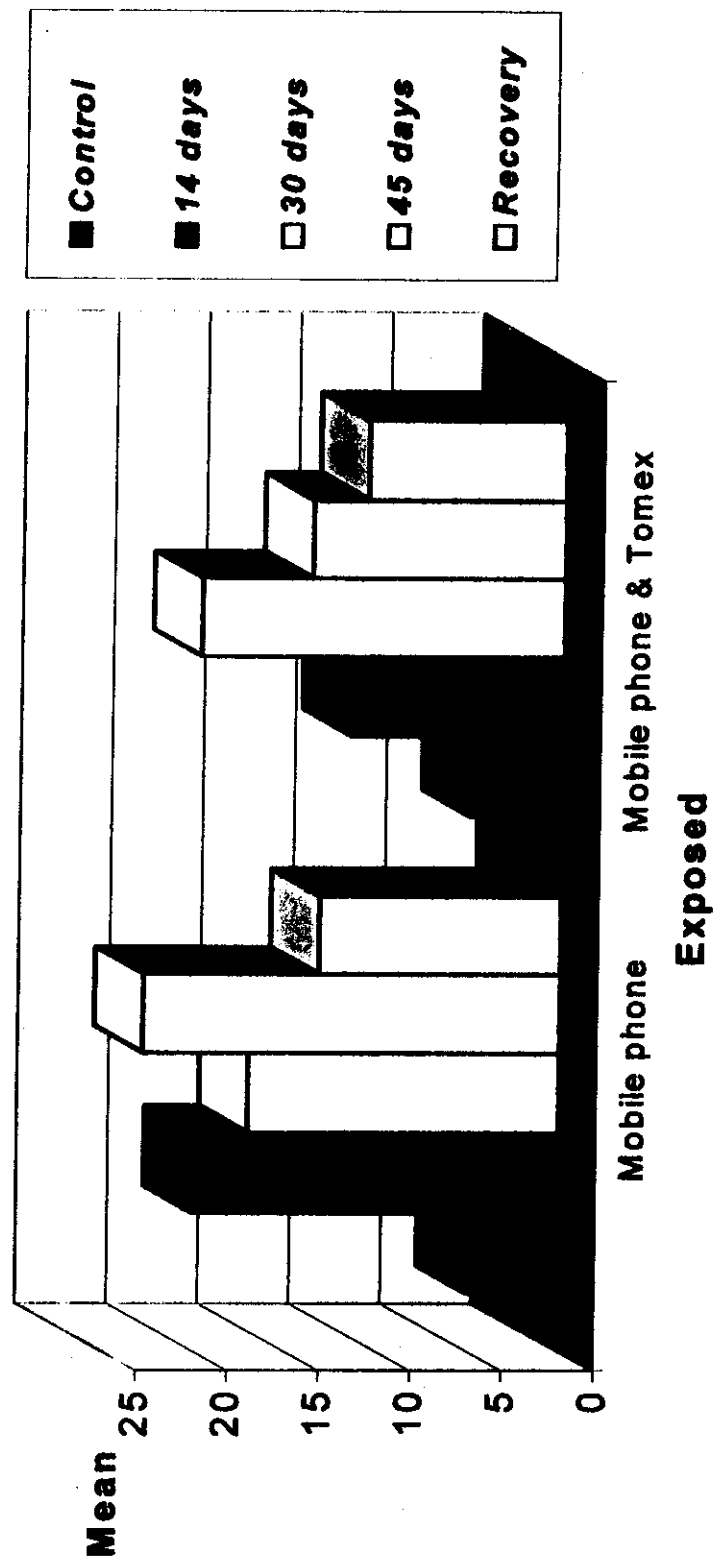


Table (2): The mean values of break in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	0.80 $\pm$ 0.84			
Microwave	1) 30 days	1.60 $\pm$ 1.52	1.21		
	2) 45 days	4.20 $\pm$ 3.35	2.26		
	3) 60 days	5.20 $\pm$ 2.17	4.27**		0.012**
	4) R	0.60 $\pm$ 0.55	0.54		
Microwave & Tomex	1) 30 days	0.60 $\pm$ 0.55	0.41	1.12	
	2) 45 days	1.20 $\pm$ 1.30	0.54	2.45	
	3) 60 days	0.60 $\pm$ 0.55	1.00	4.96**	0.142
	4) R	0.00 $\pm$ 0.00	2.14	2.45	
Mobile phone	1) 14 days	0.80 $\pm$ 0.84	0.00		
	2) 30 days	1.00 $\pm$ 1.00	0.30		
	3) 45 days	3.80 $\pm$ 1.48	3.59*		0.000***
	4) R	0.60 $\pm$ 0.55	0.54		
Mobile phone & Tomex	1) 14 days	0.60 $\pm$ 0.55	0.54	0.41	
	2) 30 days	1.80 $\pm$ 0.84	1.83	1.09	
	3) 45 days	1.00 $\pm$ 1.00	0.54	4.80**	0.078
	4) R	0.40 $\pm$ 0.89	0.59	0.34	

* Significant ($P \leq 0.05$)** Highly significant ($P \leq 0.01$)***Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig.(12a): Mean of break observed in bone marrow cells of rats exposed to microwave radiation

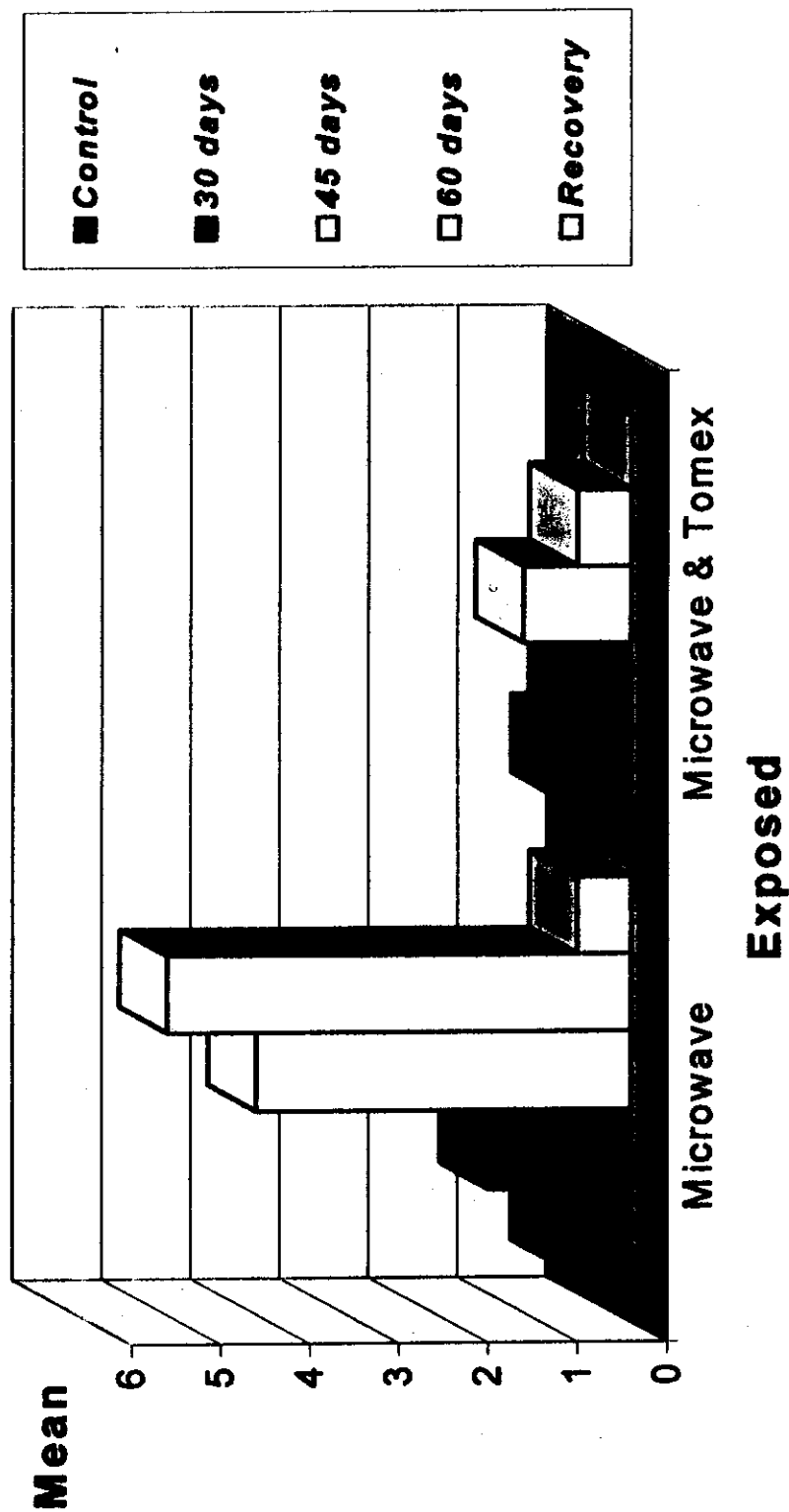
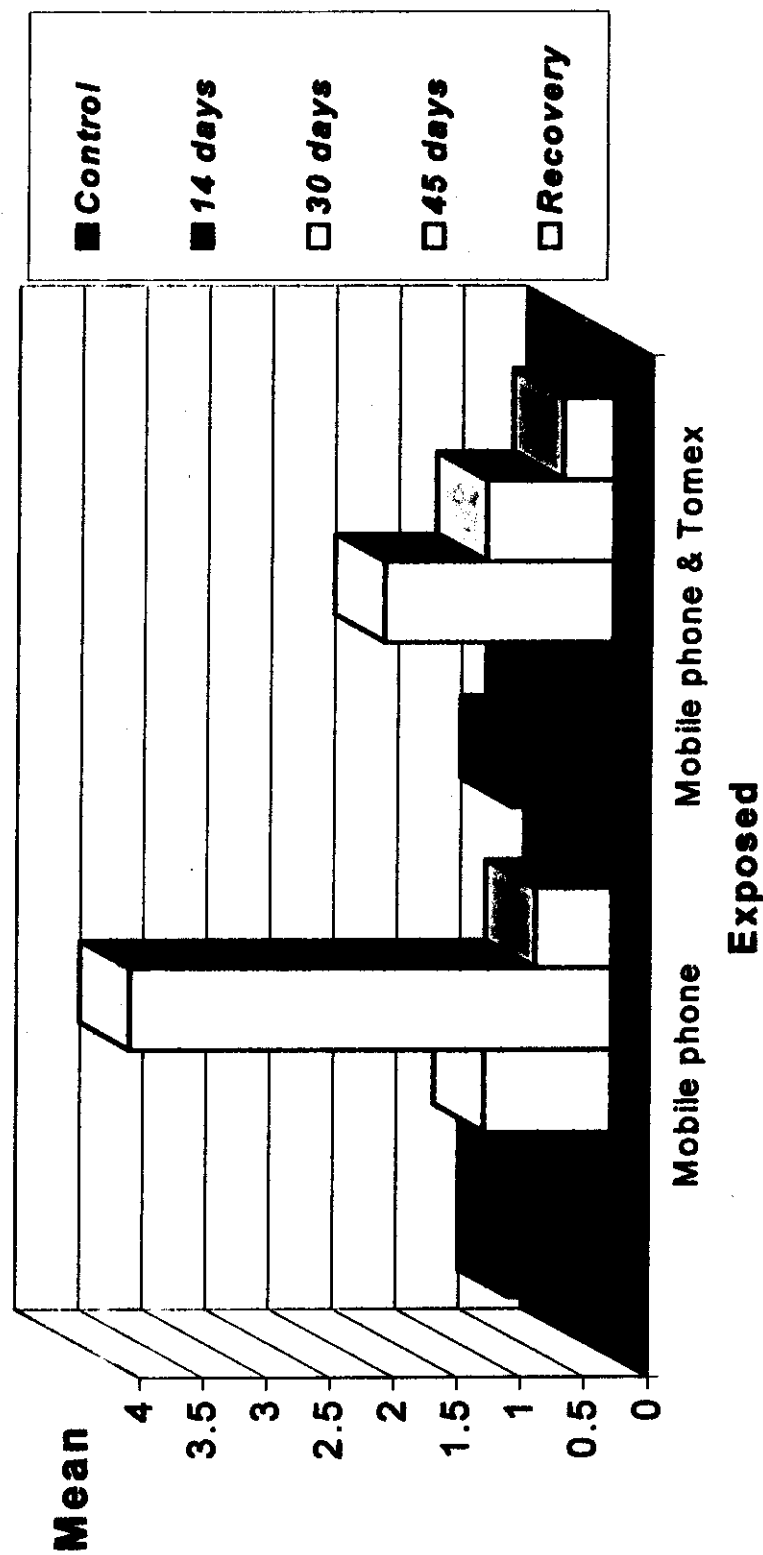


Fig.(12b): Mean of break observed in bone marrow cells of rats exposed to mobile phone radiation



Chromosome-type aberrations:

In Table (3), Fig. (13 a, b) the statistical analysis of gaps in bone marrow cells of rats exposed to microwave and mobile phone radiation indicates that, there was a significant increase of all exposed animal groups at all intervals and this increase was time dependent. Mean while the mean values of aberrant cells decreased in all groups of animals exposed to microwave and mobile phone radiation, which were daily administrated with Tomex comparing to the radiated groups except at 14 days mobile exposed group, it was increased from 7.20 ± 4.32 to 11.40 ± 5.94 . By comparing the mean values of the rats exposed to (microwave and microwave & Tomex) or exposed to (mobile and mobile tomex), a high significant difference ($t=3.50$ & $P \leq 0.05$) and ($t=2.81$ & $P \leq 0.05$) at 30 & 14 days were observed respectively. The recovery groups were decreased in some groups but also remained higher than the control one.

Table (4), Fig. (14 a, b), shows the mean value of end to end association in 50 metaphase spreads of rats exposed to microwave radiation with 9865 MHz for 30, 45 and 60 days and mobile phone radiation with 900 MHz for 14, 30 and 45 days. There was a high significant increase after 45 days in rats exposed to microwave radiation ($t=2.99$ & $P \leq 0.05$) and a highly significant increase in frequency of end-to-end association after 14 days in rats exposed to the frequency of a mobile phone ($t=5.88$ & $P \leq 0.01$) compared to the control, on the other hand there was a decrease in the mean value of all groups of animals exposed to microwave and mobile phone radiation, and were administrated with Tomex during radiation comparing to the radiated groups only. Also there was a high significant increase after 30 days of exposure to mobile phone radiation together with Tomex ($t=3.16$ & $P \leq 0.05$).

Table (3): The mean values of gaps in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	1.20 $\pm$ 1.79			
Microwave	1) 30 days	11.80 $\pm$ 4.15	4.32**		
	2) 45 days	15.20 $\pm$ 5.07	6.08**		
	3) 60 days	15.40 $\pm$ 4.93	6.39**		0.000***
	4) R	5.20 $\pm$ 1.48	6.33**		
Microwave & Tomex	1) 30 days	4.40 $\pm$ 1.14	2.99*	3.50*	
	2) 45 days	8.80 $\pm$ 3.11	7.38***	1.98	
	3) 60 days	10.40 $\pm$ 2.89	4.52**	1.62	0.000***
	4) R	4.80 $\pm$ 1.09	3.09*	0.54	
Mobile phone	1) 14 days	7.20 $\pm$ 4.32	2.89*		
	2) 30 days	13.20 $\pm$ 4.76	4.71**		
	3) 45 days	15.80 $\pm$ 7.46	3.87*		0.004**
	4) R	7.60 $\pm$ 7.09	1.77		
Mobile phone & Tomex	1) 14 days	11.40 $\pm$ 5.94	3.93*	2.81*	
	2) 30 days	10.20 $\pm$ 3.63	5.81**	1.26	
	3) 45 days	8.00 $\pm$ 3.24	3.52*	2.09	0.003***
	4) R	8.80 $\pm$ 2.05	5.73**	0.34	

* Significant ($P \leq 0.05$)** Highly significant ($P \leq 0.01$)*** Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig.(13a):Mean of chromatid gaps observed in bone marrow cells of rats exposed to microwave radiation.

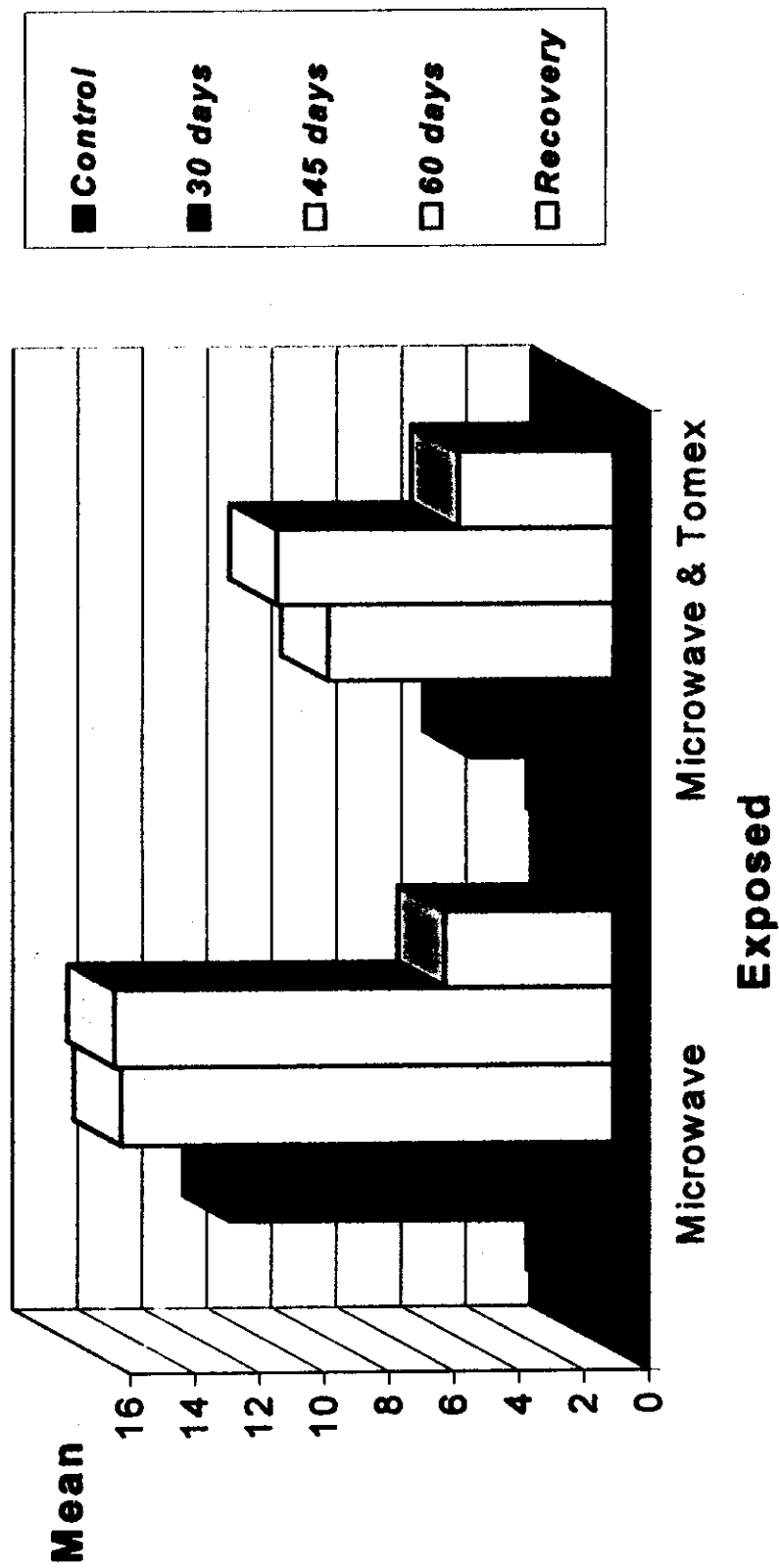


Fig.(13b): Mean of chromatid gaps observed in bone marrow cells of rats exposed to mobile phone radiation.

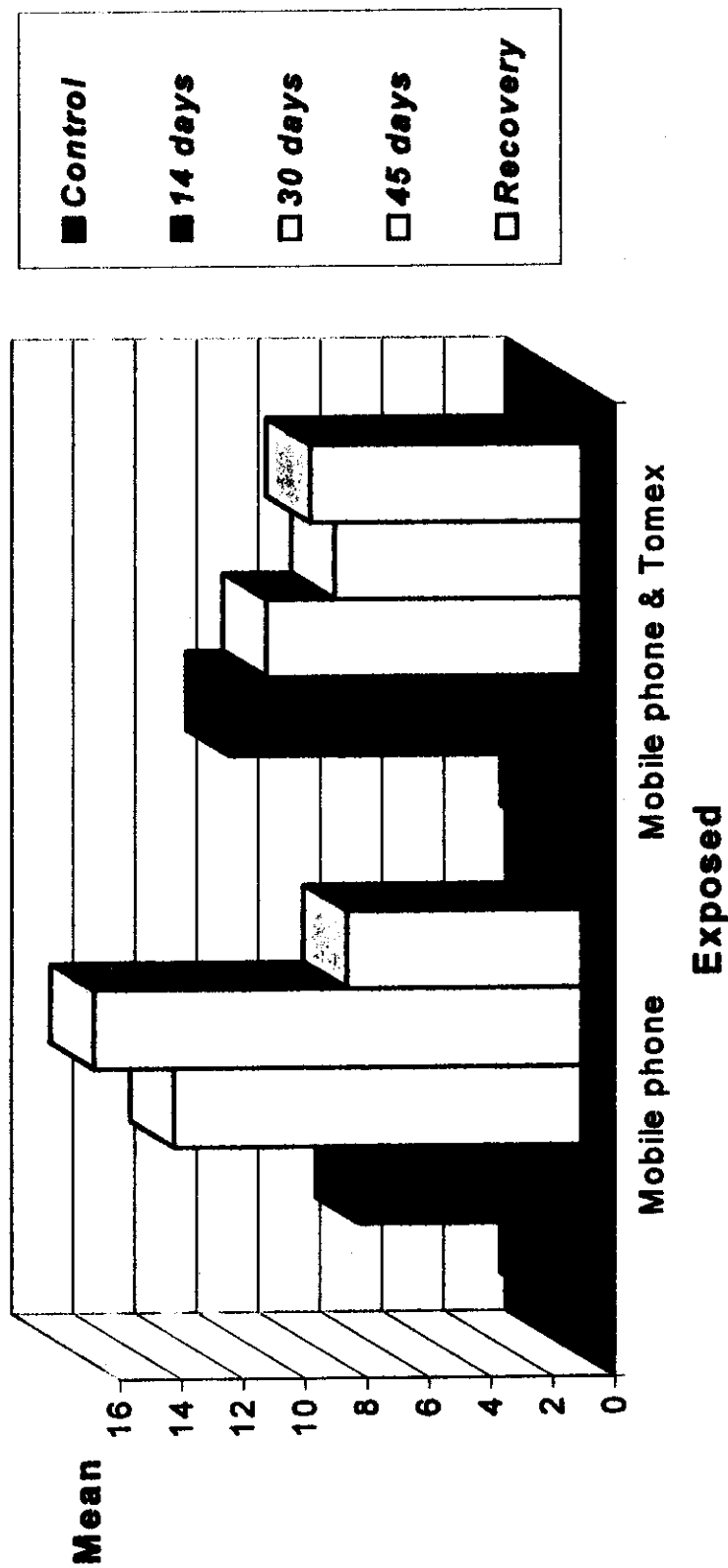


Table (4): The mean values of end to end association in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days	ANOVA Test
Control	0	0.60 $\pm$ 0.55		Radiation X Radiation & Tomex	
Microwave	1) 30 days	2.20 $\pm$ 2.68	1.24		
	2) 45 days	2.80 $\pm$ 1.30	2.99*		
	3) 60 days	1.20 $\pm$ 1.64	0.65		0.057
	4) R	0.00 $\pm$ 0.00	2.45		
Microwave & Tomex	1) 30 days	0.60 $\pm$ 0.89	0.00	1.24	
	2) 45 days	1.20 $\pm$ 1.09	1.50	2.36	
	3) 60 days	0.20 $\pm$ 0.45	1.63	1.19	0.225
	4) R	0.20 $\pm$ 0.45	1.00	1.00	
Mobile phone	1) 14 days	2.80 $\pm$ 0.84	5.88**		
	2) 30 days	1.80 $\pm$ 1.09	1.81		
	3) 45 days	1.20 $\pm$ 2.17	0.51		0.095
	4) R	0.80 $\pm$ 1.30	0.27		
Mobile phone & Tomex	1) 14 days	1.40 $\pm$ 1.14	1.21	1.72	
	2) 30 days	1.60 $\pm$ 0.55	3.16*	0.34	
	3) 45 days	0.60 $\pm$ 0.89	0.00	1.00	0.123
	4) R	0.60 $\pm$ 0.55	0.00	0.27	

* Significant ($P \leq 0.05$)** Highly significant ($P \leq 0.01$)***Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig.(14a): Mean of end to end association observed in bone marrow cells of rats exposed to microwave radiation

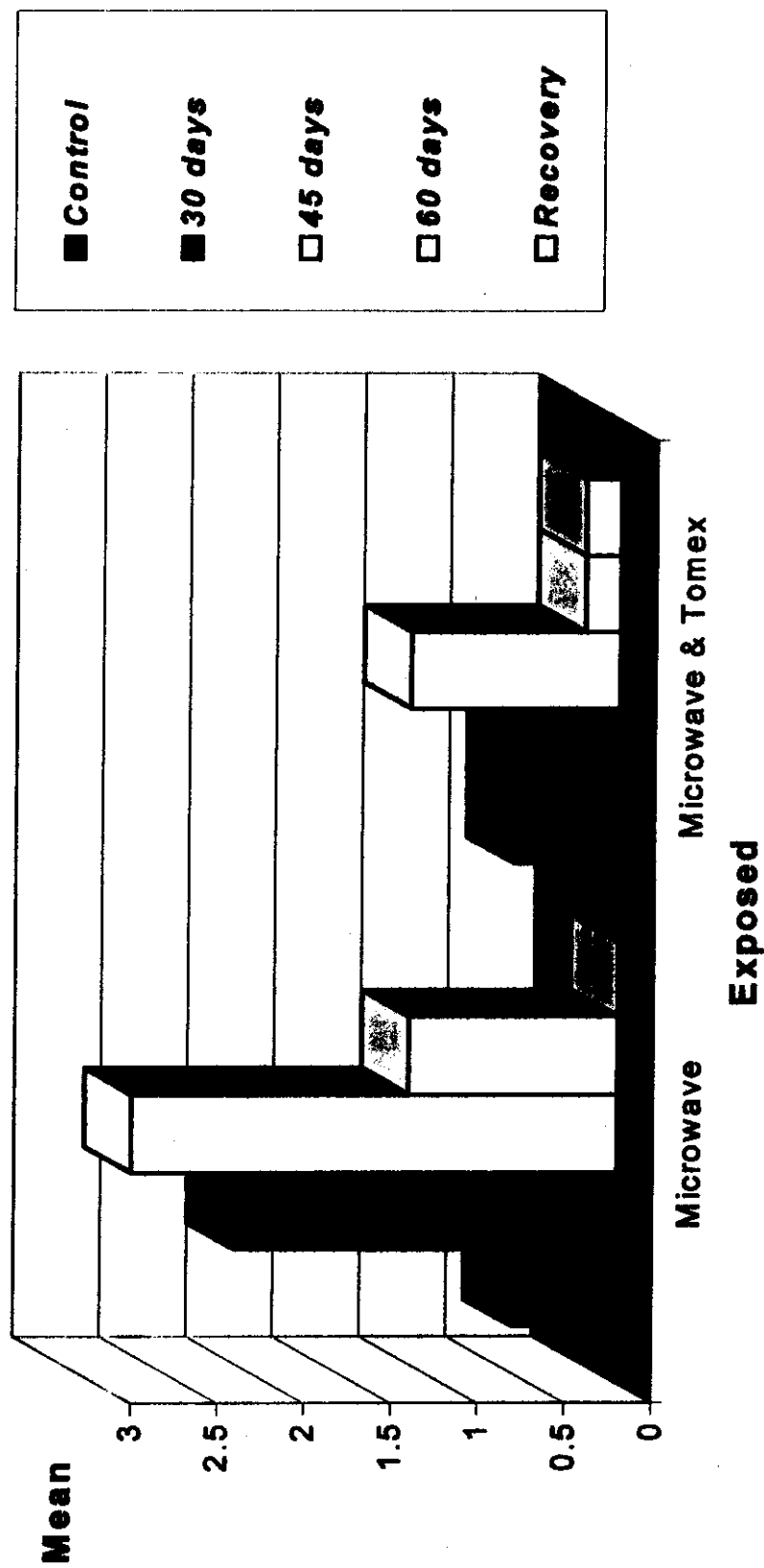
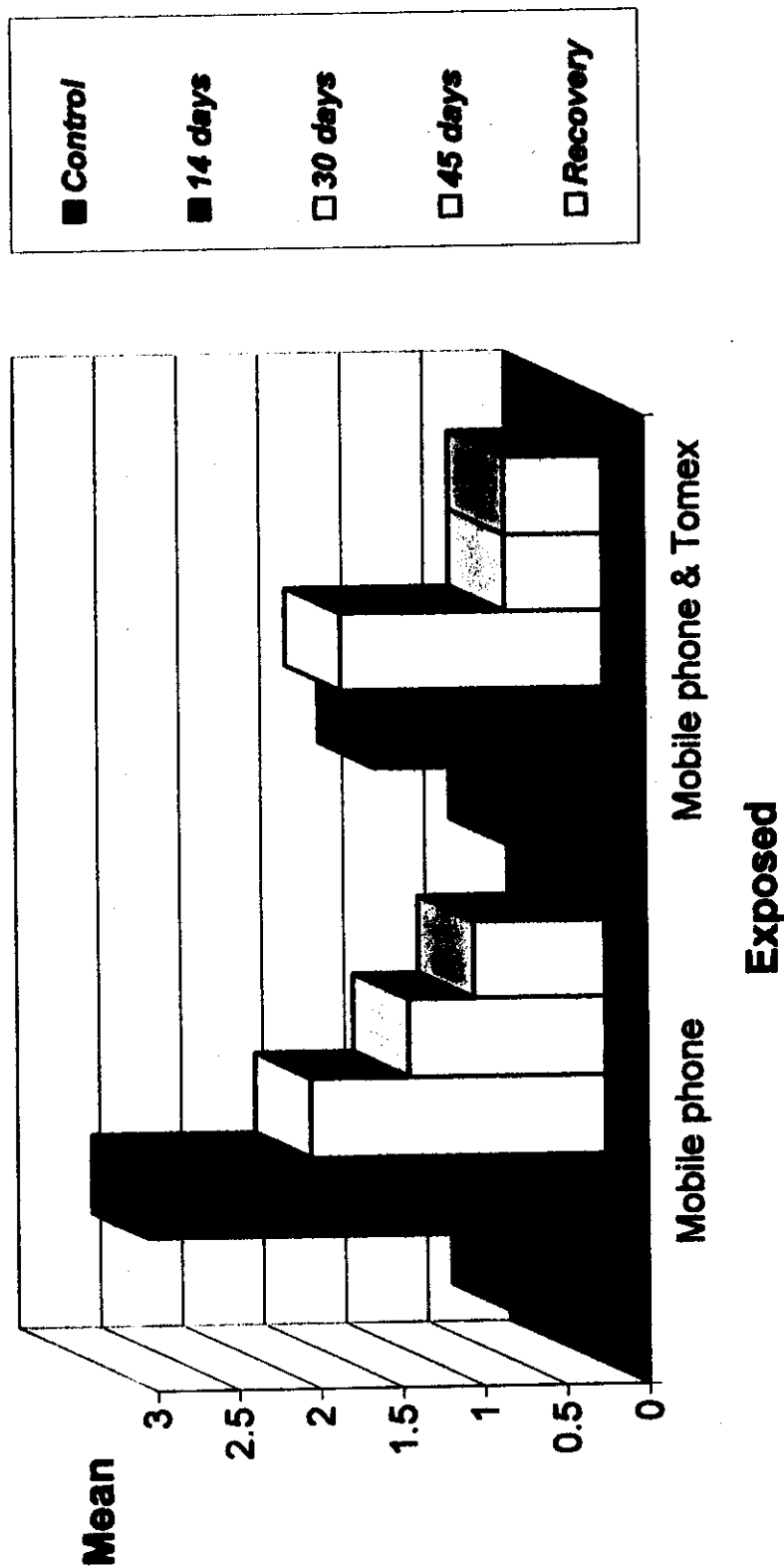


Fig.(14b): Mean of end to end association observed in bone marrow cells of rats exposed to mobile phone radiation



There was no significant increase of centric fusion in cells of rats exposed to microwave radiation but in rats exposed to mobile phone radiation the only increase in centric fusion was after 30 days ($t=3.16$ & $P\leq 0.05$) comparing to the control, but the mean value of all exposed groups still higher than the control one. (Table 5) (Fig. 15 a, b).

Table (6), Fig. (16 a, b), shows a significant increase in centromeric attenuation in cells of rats exposed to microwave radiation of 9865 MHz while in rats exposed to mobile phone frequency of 900 MHz the significant was found after 14 and 30 days of exposure comparing to the control group. There was a decrease in the mean value of all groups of animals exposed to microwave and mobile phone radiation, which were daily administrated with 0.1 ml Tomex comparing to the exposed groups. Comparing the mean values of centromeric attenuation in animals exposed to (microwave and microwave Tomex) groups, showed significant decrease at 45 and 60 days ($t=2.76$ & $P\leq 0.05$) and ($t=4.80$ & $P\leq 0.01$) respectively while in rats exposed to (mobile phone and mobile phone & Tomex) groups the mean values were very highly significant decreased ($t=10.16$ & $P\leq 0.001$) after 30 days.

Table (7), Fig. (17 a, b) represents the mean values of ring chromosome in 50 metaphase spreads of rats exposed to microwave and to mobile phone radiation. There was no significant difference between all the exposed groups except at 45 days of rats exposed to 9865 MHz microwave radiation ($t=3.09$ & $P\leq 0.05$) and after 30, 45 days of rats exposed to 900 MHz mobile phone radiation ($t=4.47$ & $P\leq 0.05$) and ($t=3.67$ & $P\leq 0.05$) but the mean value of all exposed groups still higher than the unexposed group (control). By comparing the mean values of rats exposed to (mobile phone and mobile phone & Tomex) groups, there was a significant decrease at 30 & 45 days ($t=3.50$ & $P\leq 0.05$) and ($t=3.67$ & $P\leq 0.05$) respectively.

Table (5): The mean values of centric fusion in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	0.20 $\pm$ 0.45			
Microwave	1) 30 days	1.40 $\pm$ 2.07	1.63		
	2) 45 days	1.00 $\pm$ 1.00	2.14		
	3) 60 days	1.20 $\pm$ 1.30	1.83		0.620
	4) R	0.80 $\pm$ 0.84	1.18		
Microwave & Tomex	1) 30 days	0.20 $\pm$ 0.45	0.00	1.24	
	2) 45 days	1.00 $\pm$ 1.23	1.21	0.00	
	3) 60 days	0.80 $\pm$ 0.84	1.50	0.49	0.584
	4) R	0.60 $\pm$ 1.34	0.59	0.30	
Mobile phone	1) 14 days	0.20 $\pm$ 0.45	0.00		
	2) 30 days	1.20 $\pm$ 1.09	3.16*		
	3) 45 days	1.40 $\pm$ 1.34	2.45		0.000***
	4) R	0.40 $\pm$ 0.55	0.54		
Mobile phone & Tomex	1) 14 days	1.40 $\pm$ 1.14	2.06	2.06	
	2) 30 days	0.80 $\pm$ 0.84	1.50	0.78	
	3) 45 days	0.00 $\pm$ 0.00	1.00	2.33	0.040*
	4) R	0.40 $\pm$ 0.55	1.00	0.00	

* Significant ($P \leq 0.05$)** Highly significant ($P \leq 0.01$)*** Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig.(15a): Mean value of centric fusion observed in bone marrow cells of rats exposed to microwave radiation

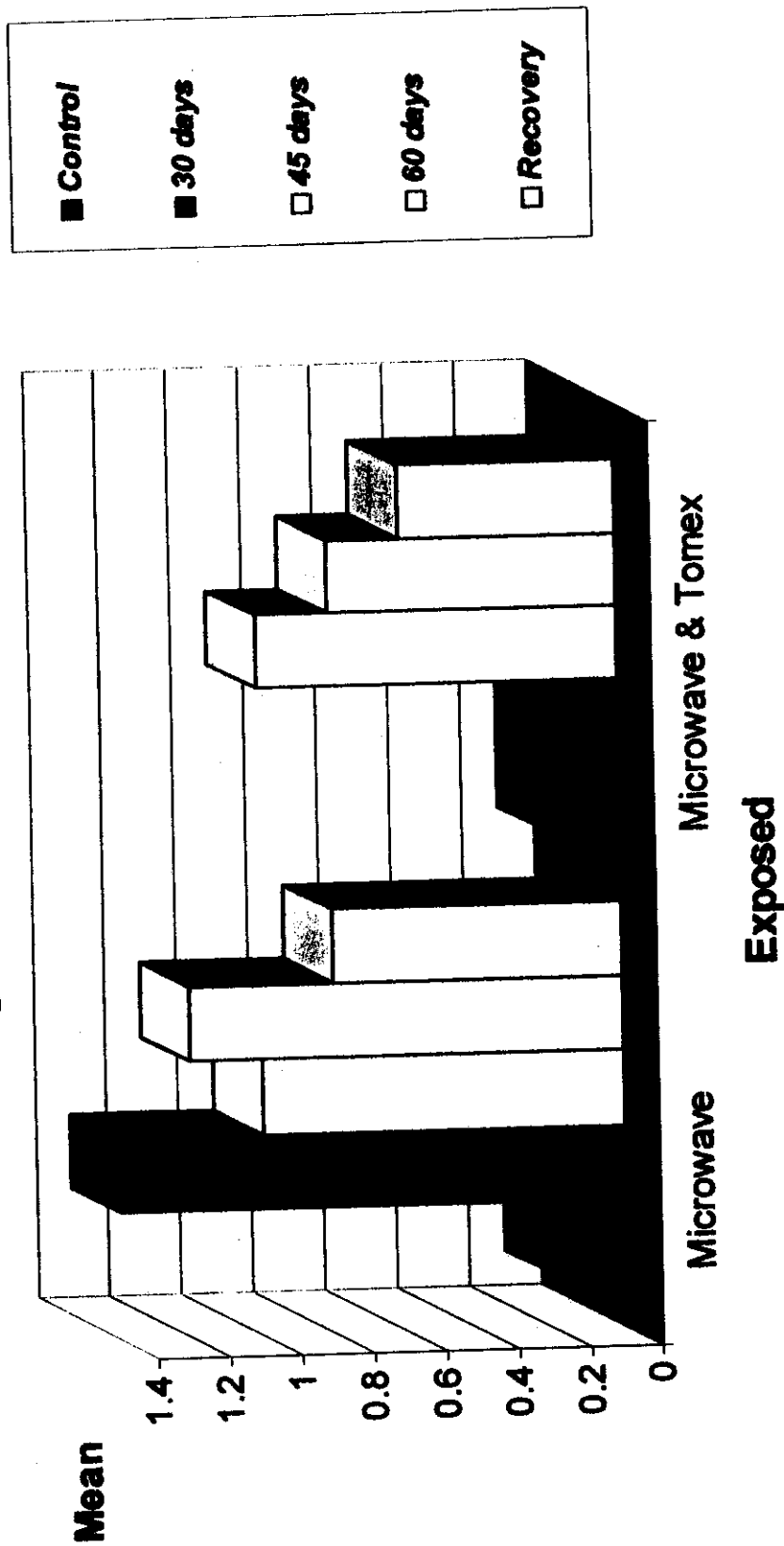


Fig.(15b): Mean value of centric fusion observed in bone marrow cells of rats exposed to mobile phone radiation.

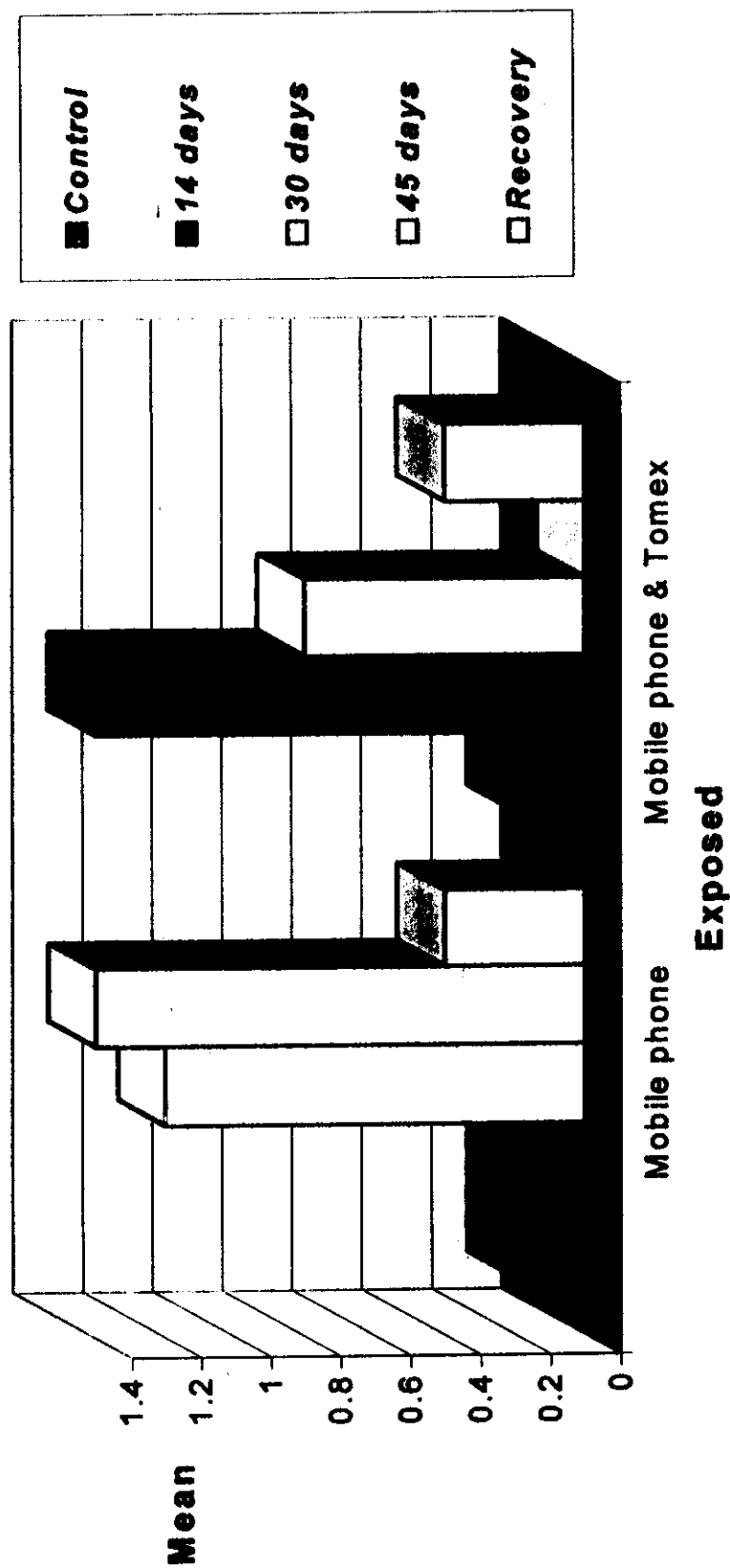


Table (6): The mean values of centromeric attenuation in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	0.80 $\pm$ 0.84			
Microwave	1) 30 days	3.00 $\pm$ 1.00	2.99*		
	2) 45 days	4.80 $\pm$ 1.30	7.30***		
	3) 60 days	4.00 $\pm$ 0.71	5.49**		0.000***
	4) R	0.80 $\pm$ 0.45	0.00		
Microwave & Tomex	1) 30 days	1.80 $\pm$ 1.79	1.41	1.12	
	2) 45 days	1.60 $\pm$ 1.34	0.93	2.76*	
	3) 60 days	1.20 $\pm$ 0.84	1.00	4.80**	0.7000
	4) R	1.40 $\pm$ 0.55	1.50	1.50	
Mobile phone	1) 14 days	5.00 $\pm$ 2.00	4.33**		
	2) 30 days	4.00 $\pm$ 0.71	4.82**		
	3) 45 days	2.00 $\pm$ 2.35	1.18		0.004**
	4) R	2.00 $\pm$ 0.71	1.31		
Mobile phone & Tomex	1) 14 days	0.80 $\pm$ 0.84	0.00	3.38*	
	2) 30 days	0.20 $\pm$ 0.20	1.18	10.16***	
	3) 45 days	0.80 $\pm$ 0.58	0.00	2.06	0.796
	4) R	0.60 $\pm$ 0.40	0.30	1.51	

* Significant ($P \leq 0.05$)** Highly significant ($P \leq 0.01$)*** Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig.(16a): Mean of centromeric attenuation observed in bone marrow cells of rats exposed to microwave radiation.

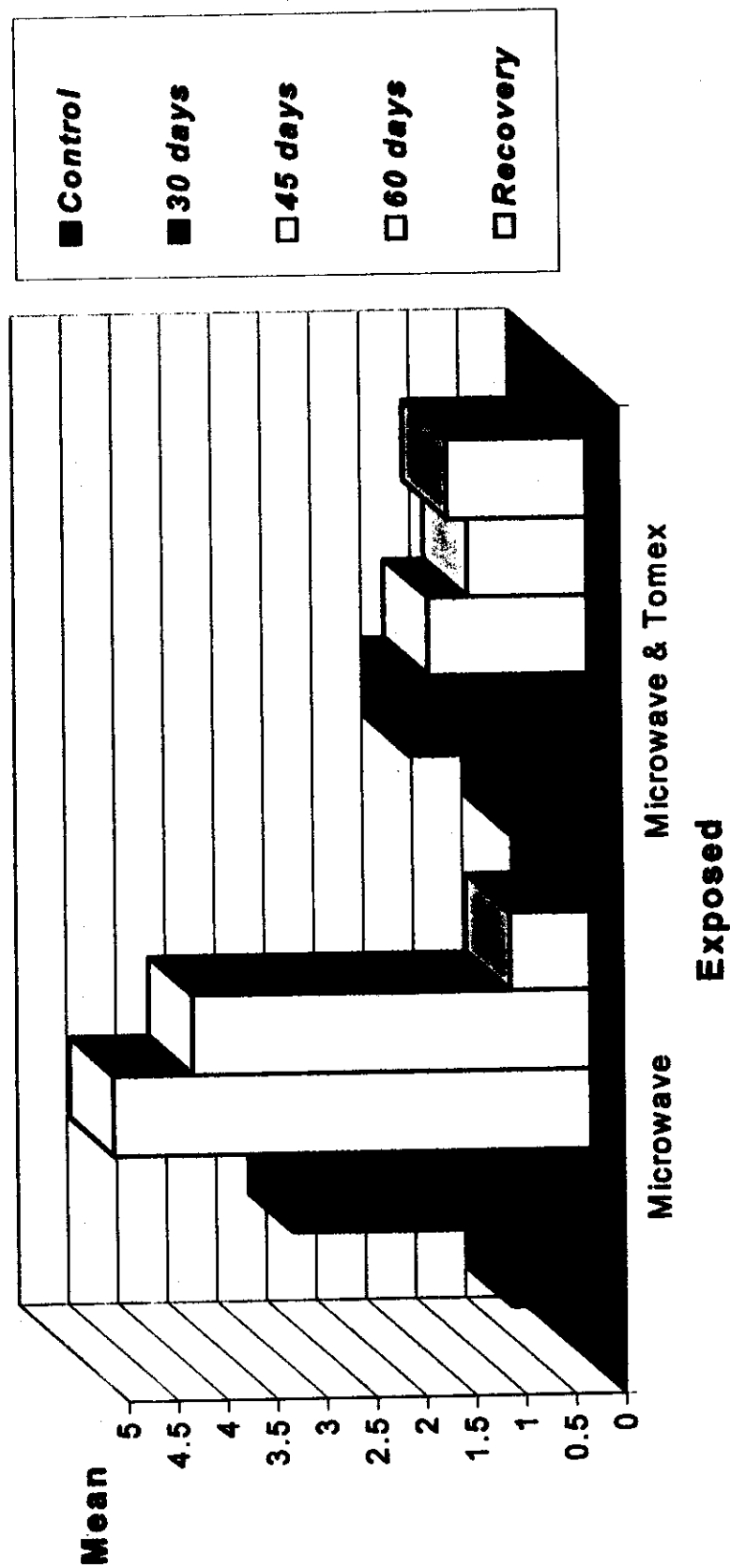


Fig.(16b): Mean of centromeric attenuation observed in bone marrow cells of rats exposed to mobile phone radiation.

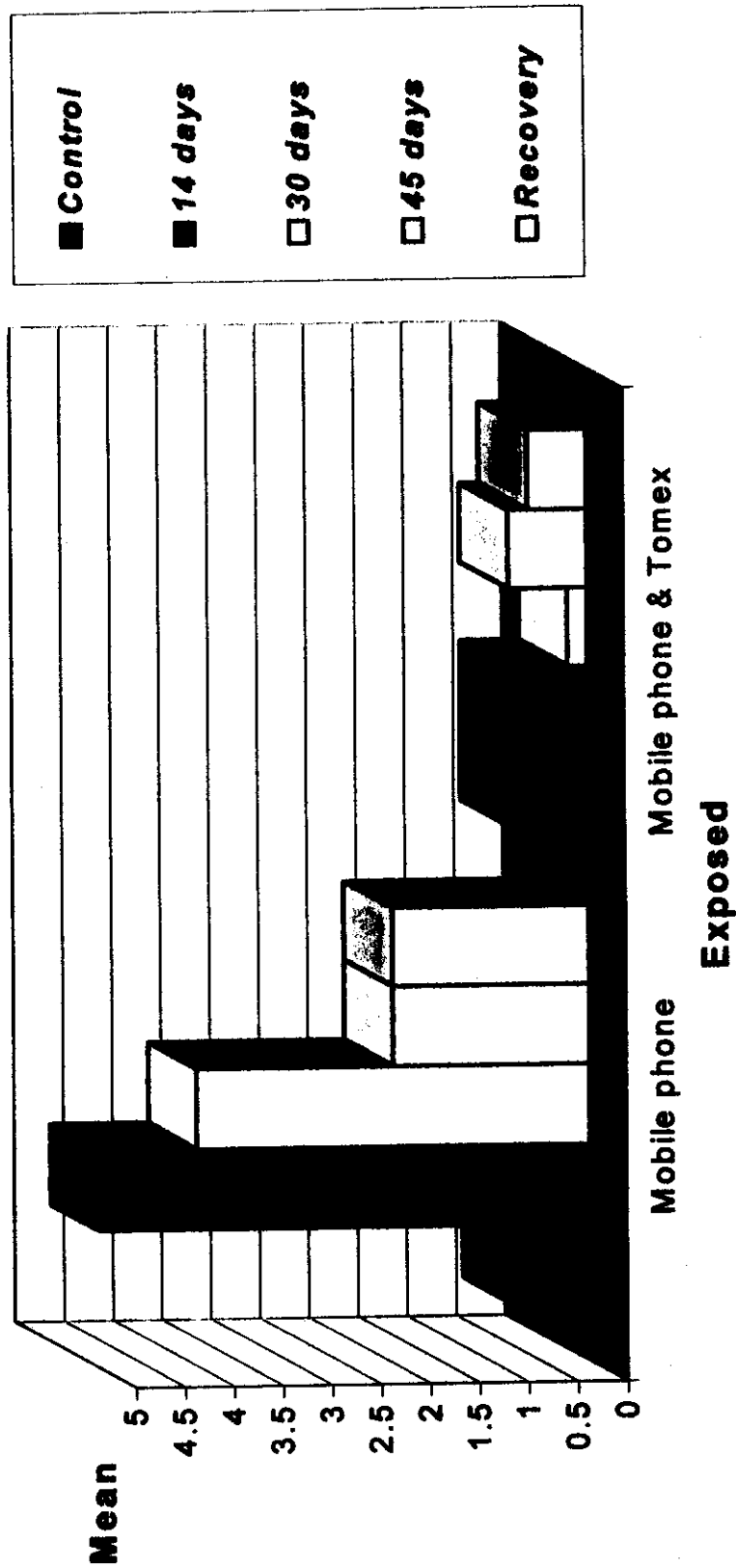


Table (7): The mean values of ring chromosomes in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	0.00 $\pm$ 0.00			
Microwave	1) 30 days	0.40 $\pm$ 0.89	1.00		0.058
	2) 45 days	1.80 $\pm$ 1.30	3.09*		
	3) 60 days	1.00 $\pm$ 1.23	1.83		
	4) R	0.00 $\pm$ 0.00	0.00		
Microwave & Tomex	1) 30 days	0.00 $\pm$ 0.00	0.00	1.00	0.006**
	2) 45 days	1.00 $\pm$ 1.23	1.83	0.78	
	3) 60 days	2.40 $\pm$ 1.34	4.00*	2.33	
	4) R	0.40 $\pm$ 0.55	1.63	1.63	
Mobile phone	1) 14 days	0.20 $\pm$ 0.45	1.00		0.016*
	2) 30 days	2.00 $\pm$ 1.00	4.47**		
	3) 45 days	1.80 $\pm$ 1.09	3.67*		
	4) R	0.80 $\pm$ 0.84	2.14		
Mobile phone & Tomex	1) 14 days	1.60 $\pm$ 1.52	2.36	2.33	0.035*
	2) 30 days	0.60 $\pm$ 0.89	1.50	3.50*	
	3) 45 days	0.00 $\pm$ 0.00	0.00	3.67*	
	4) R	0.00 $\pm$ 0.00	0.00	2.14	

* Significant ($P \leq 0.05$)** Highly significant ($P \leq 0.01$)*** Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig.(17a): Mean of ring chromosomes observed in bone marrow cells of rats exposed to microwave radiation.

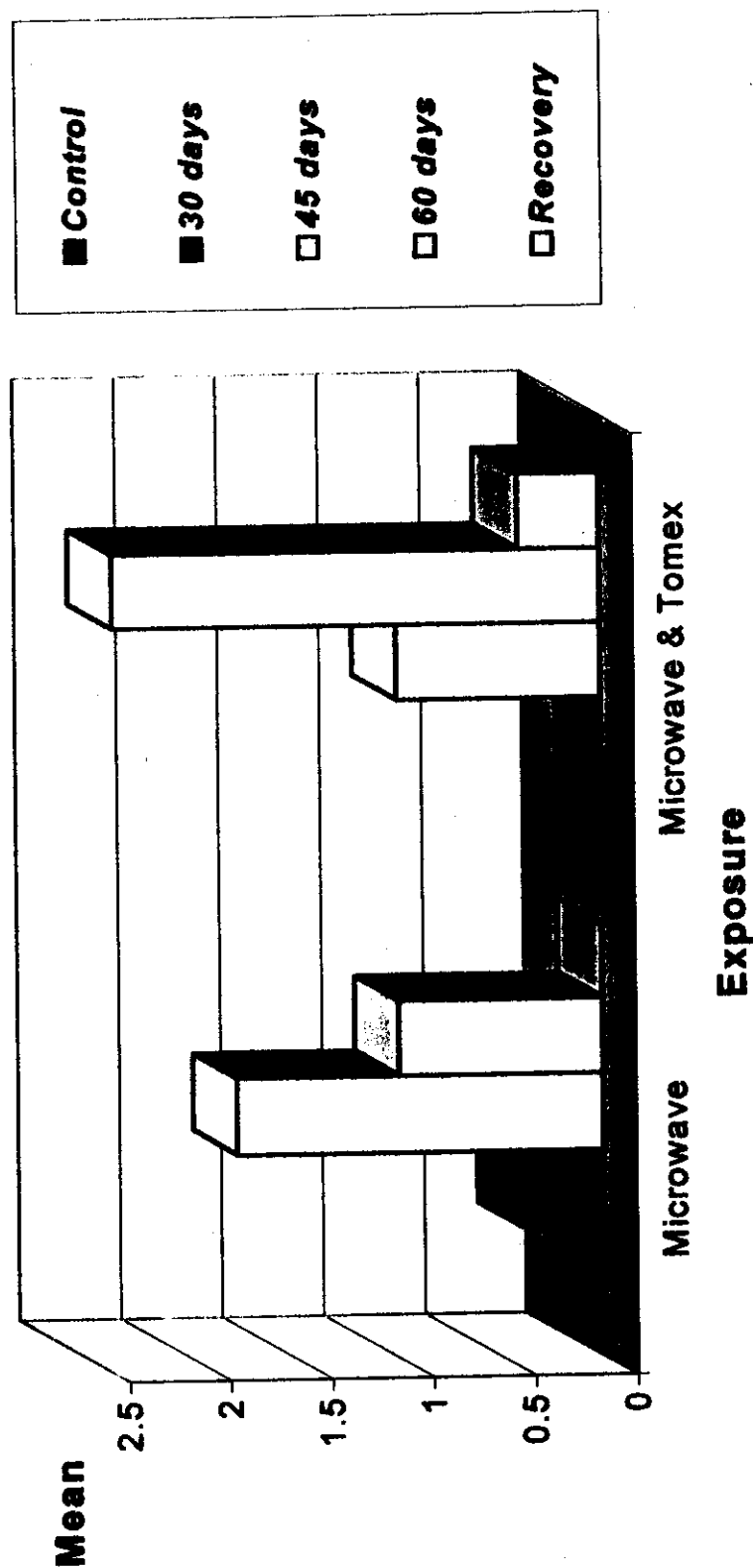


Fig. (17b): Mean of ring chromosomes observed in bone marrow cells of rats exposed to mobile phone radiation.

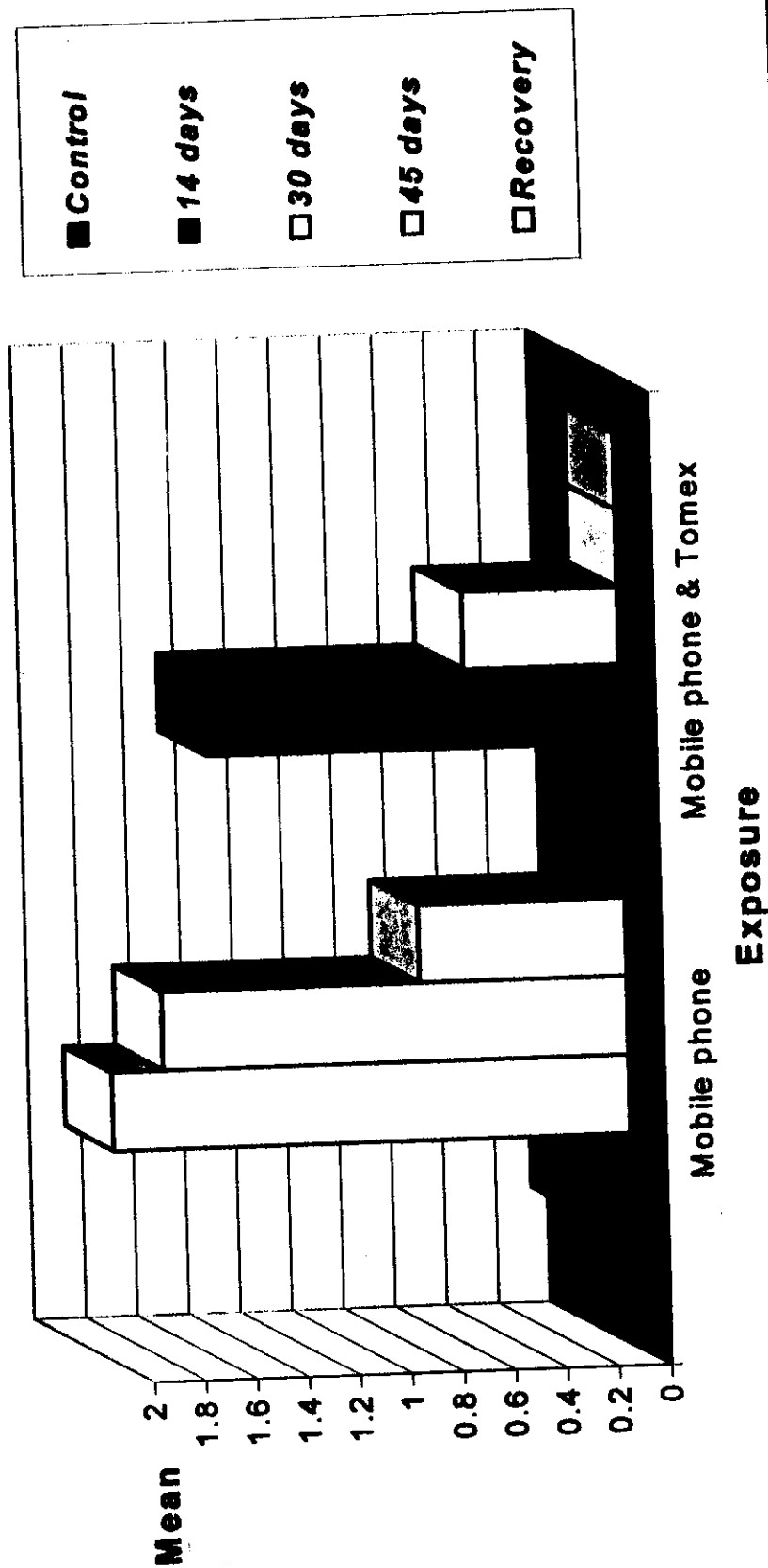


Table (8), Fig. (18 a, b), shows the mean values of stickness in bone marrow cells. There was no significant difference neither in microwave groups nor in mobile phone groups except after 30 days in rats exposed to microwave radiation ($t=3.29$ & $P\leq 0.05$) but the mean value remained higher in all exposed groups compared to the control one.

In the present study the mitotic index (MI), which equals to the number of metaphases per 1000 cell was examined and showed that the MI was decreased in microwave and mobile phone groups comparing to the control (Table 9) (Fig. 19 a, b). The percentage of MI reached 39.04%, 39.06%, 43.80% at 30, 45 and 60 days, respectively, when compared to 47.04% in the control group for rats exposed to microwave radiation while in rats exposed to mobile radiation the percentage was 39.10%, 42.22%, 33.42% at 14, 30 and 45 days, respectively, comparing to the control (47.04%). In the microwave exposed groups which were administrated with Tomex there was an increase in the MI reached 46.78%, 49.40%, 47.76% at 30, 45 and 60 days respectively when compared to 47.04% in the control group. While in rats exposed to mobile phone radiation the percentage was 43.30%, 46.02%, 45.26% at 14, 30 and 45 days respectively comparing to the control that is to say it reached the normal condition.

Table (10), Fig. (20 a, b), shows the mean values of total structural aberrations of rats exposed to microwave with 9865 MHz for 30, 45 and 60 days or to mobile phone radiation with 900 MHz for 14, 30 and 45 days. There was a highly significant increase in all exposed groups comparing to control one. Also there was a noticeable decrease in the mean values of the recovery (30 days after post exposure) in the total structural aberrations of all exposed groups, but the mean values of the groups which were administrated daily with 0.1ml Tomex was lesser than the other recovery

Table (8): The mean values of stickiness in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	5.20 $\pm$ 1.30			
Microwave	1) 30 days	16.00 $\pm$ 7.07	3.29*		0.015*
	2) 45 days	10.00 $\pm$ 6.00	1.70		
	3) 60 days	9.00 $\pm$ 4.00	2.48		
	4) R	6.00 $\pm$ 3.08	0.50		
Microwave & Tomex	1) 30 days	7.20 $\pm$ 1.48	2.24	3.37*	0.043*
	2) 45 days	14.00 $\pm$ 8.46	2.05	0.79	
	3) 60 days	6.60 $\pm$ 4.16	0.69	0.75	
	4) R	6.40 $\pm$ 3.05	0.66	0.36	
Mobile phone	1) 14 days	5.20 $\pm$ 2.49	0.00		0.081
	2) 30 days	5.20 $\pm$ 3.27	0.00		
	3) 45 days	10.40 $\pm$ 5.59	1.86		
	4) R	9.20 $\pm$ 4.15	2.27		
Mobile phone & Tomex	1) 14 days	4.80 $\pm$ 3.77	0.27	0.20	0.513
	2) 30 days	11.80 $\pm$ 14.89	1.06	1.19	
	3) 45 days	9.20 $\pm$ 4.15	0.12	1.81	
	4) R	8.60 $\pm$ 4.62	1.83	0.27	

* Significant ($P \leq 0.05$)

** Highly significant ($P \leq 0.01$)

***Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig. (18a): Mean of stickiness in bone marrow cells of rats exposed to microwave radiation.

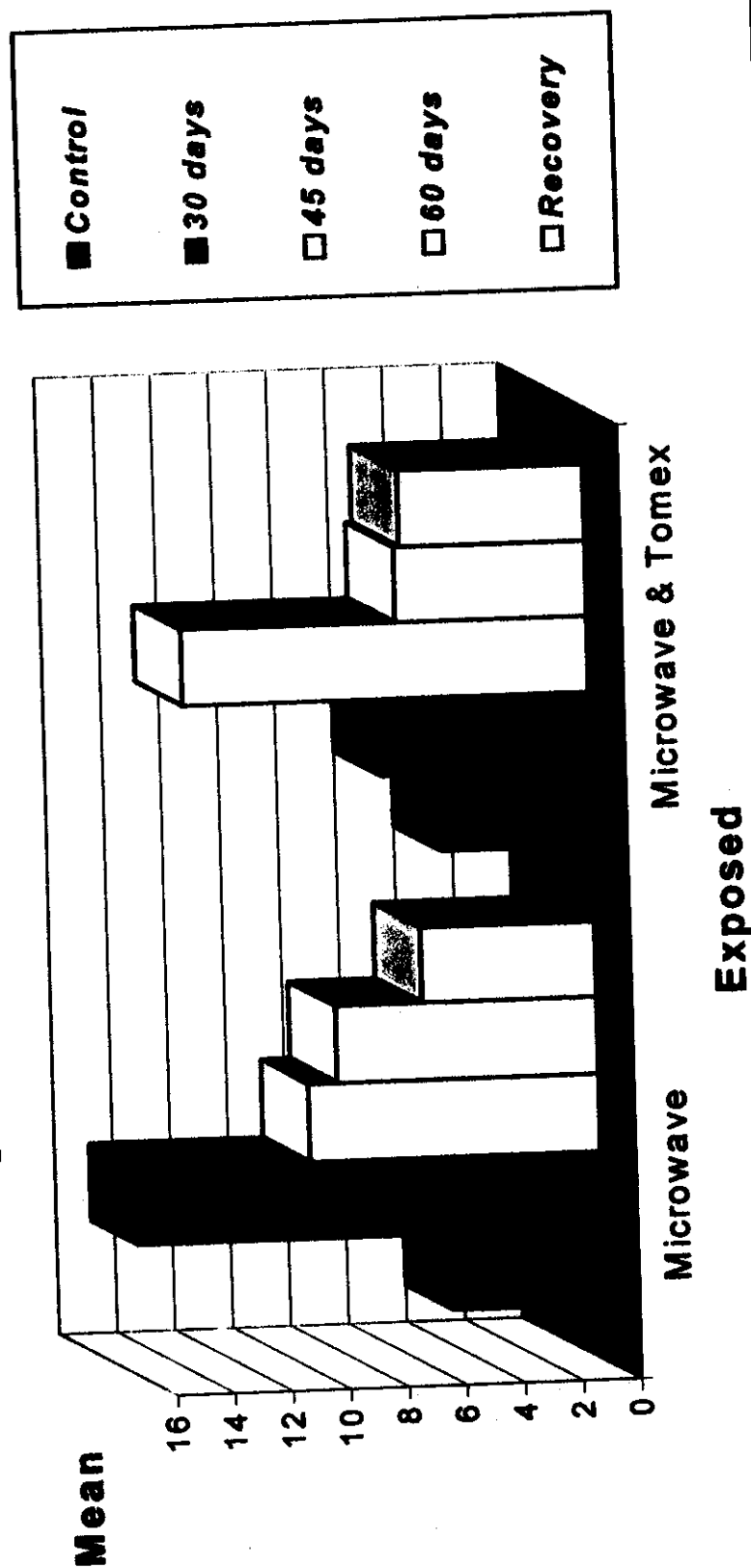


Fig. (18b): Mean of sickness observed in bone marrow cells of rats exposed to mobile phone radiation

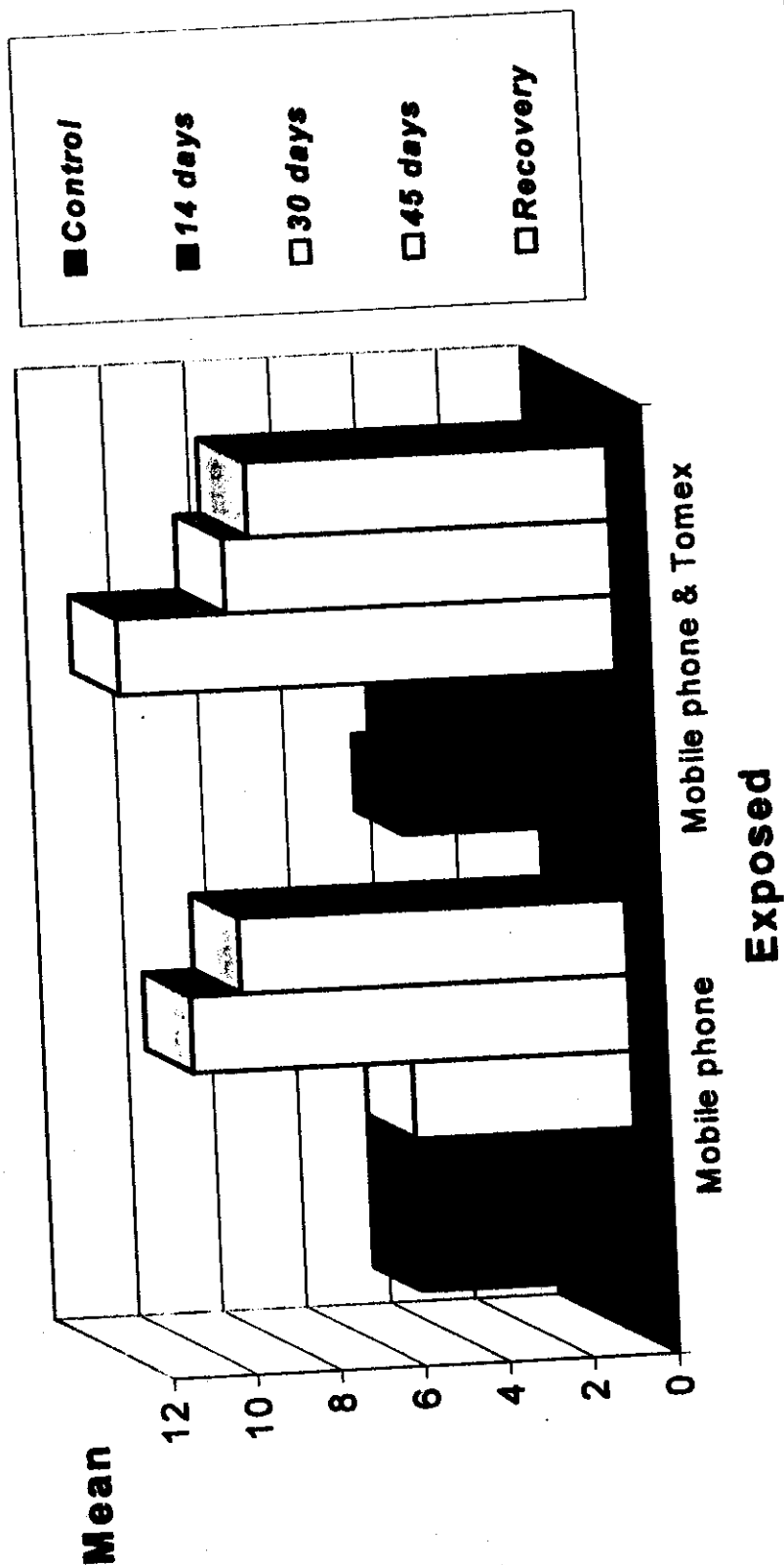


Table (9): The mean values of mitotic index in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	%	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	470.40 $\pm$ 42.64	47.04%			
Microwave	1) 30 days	390.40 $\pm$ 25.11	39.04%	2.42		
	2) 45 days	390.60 $\pm$ 42.65	39.06%	2.23		
	3) 60 days	438.00 $\pm$ 93.89	43.80%	1.30		0.196
	4) R	345.80 $\pm$ 29.53	34.58%	5.23**		
Microwave & Tomex	1) 30 days	467.80 $\pm$ 24.17	46.78%	0.09	2.67*	
	2) 45 days	494.00 $\pm$ 31.82	49.40%	0.86	3.77*	
	3) 60 days	477.60 $\pm$ 45.27	47.76%	0.84	1.06	0.000***
	4) R	290.80 $\pm$ 38.60	29.08%	4.94**	2.49	
Mobile phone	1) 14 days	391.00 $\pm$ 41.89	39.10%	1.76		
	2) 30 days	422.20 $\pm$ 58.61	42.22%	1.24		0.005**
	3) 45 days	334.20 $\pm$ 52.64	33.42%	3.83*		
	4) R	257.60 $\pm$ 20.91	25.76%	8.74***		
Mobile phone & Tomex	1) 14 days	433.00 $\pm$ 74.79	43.30%	1.47	0.71	
	2) 30 days	460.20 $\pm$ 68.77	46.02%	0.28	1.68	
	3) 45 days	452.60 $\pm$ 110.03	45.26%	0.27	2.89*	0.359
	4) R	372.40 $\pm$ 70.41	37.24%	3.99*	3.10*	

* Significant ($P \leq 0.05$)** Highly significant ($P \leq 0.01$)***Very highly significant ($P \leq 0.001$)

R = Recovery (30 day after post exposure)

Fig.(19a): The mean value of mitotic index in bone marrow cells of rats exposed to microwave radiation.

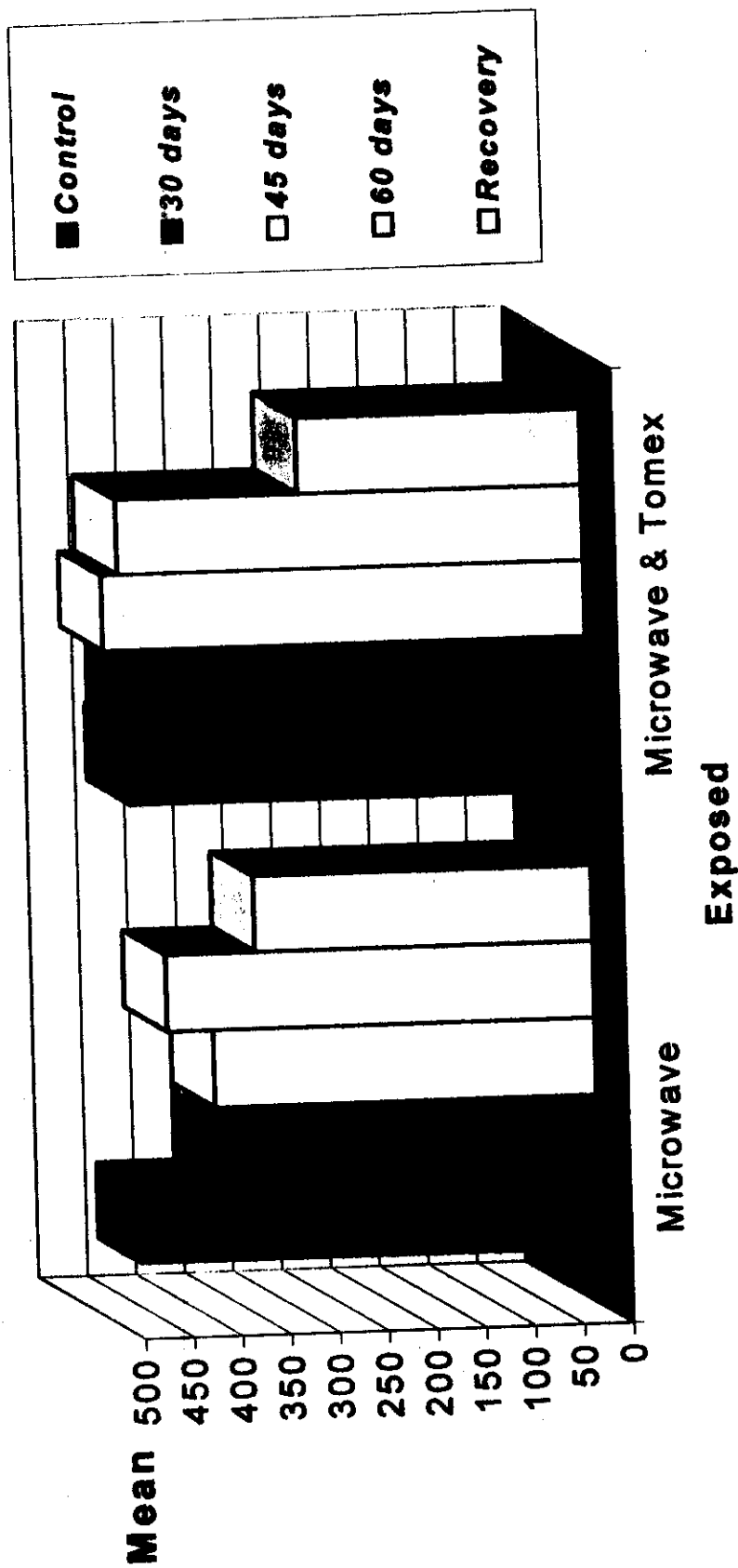


Fig.(19b):The mean value of mitotic index in bone marrow cells of rats exposed to mobile radiation.

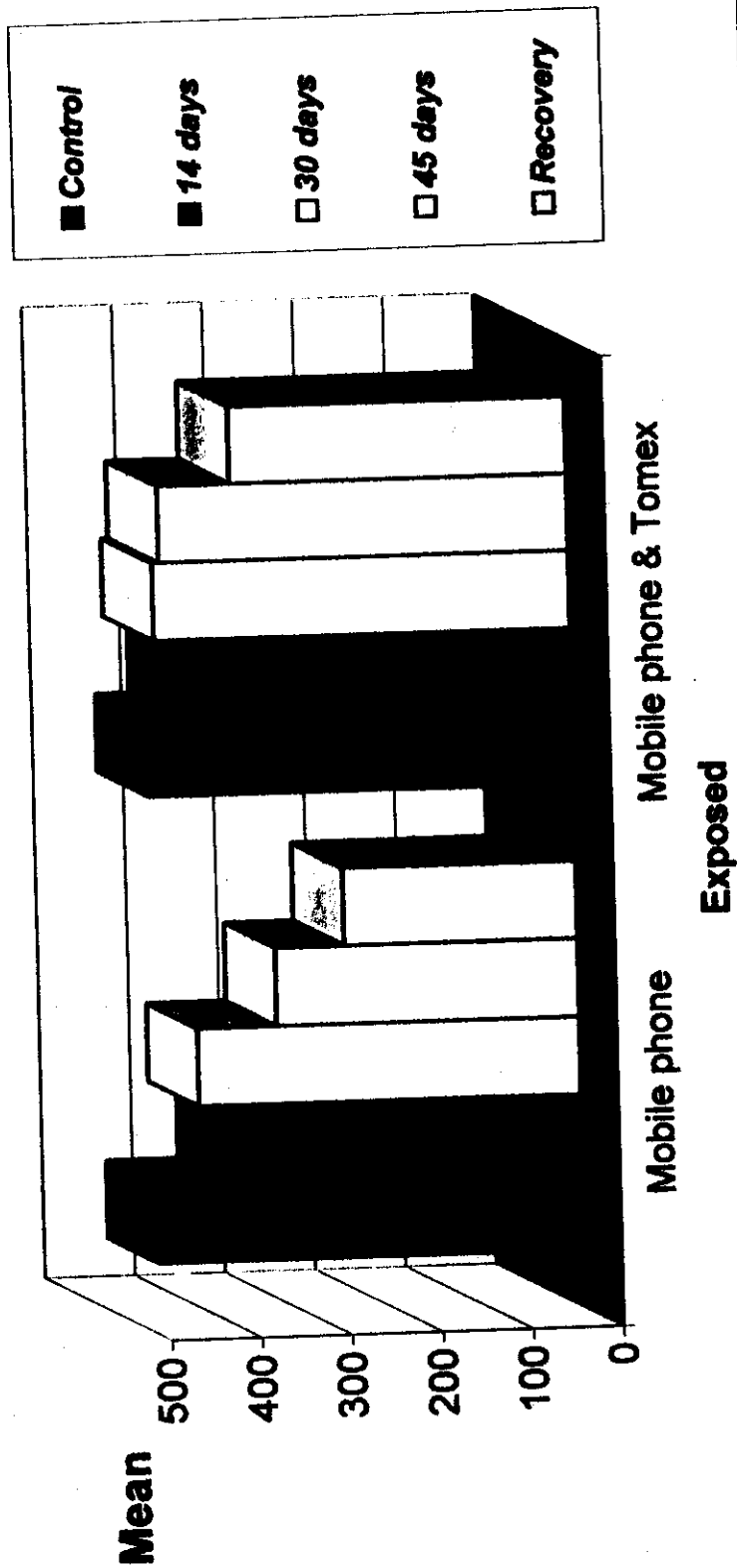


Fig. (20a): Mean values of total structural aberration observed in bone marrow cells of rats exposed to microwave radiation.

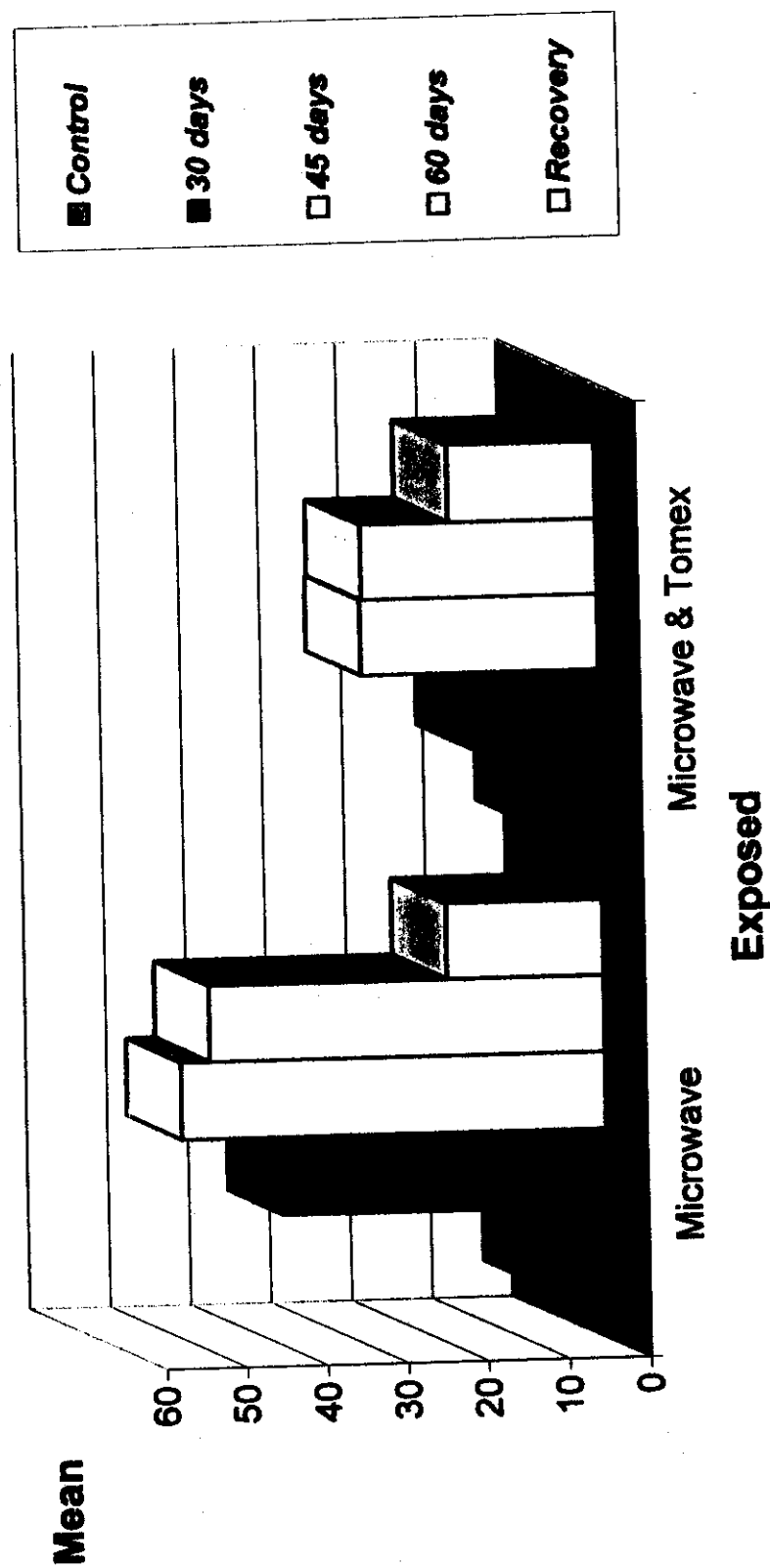
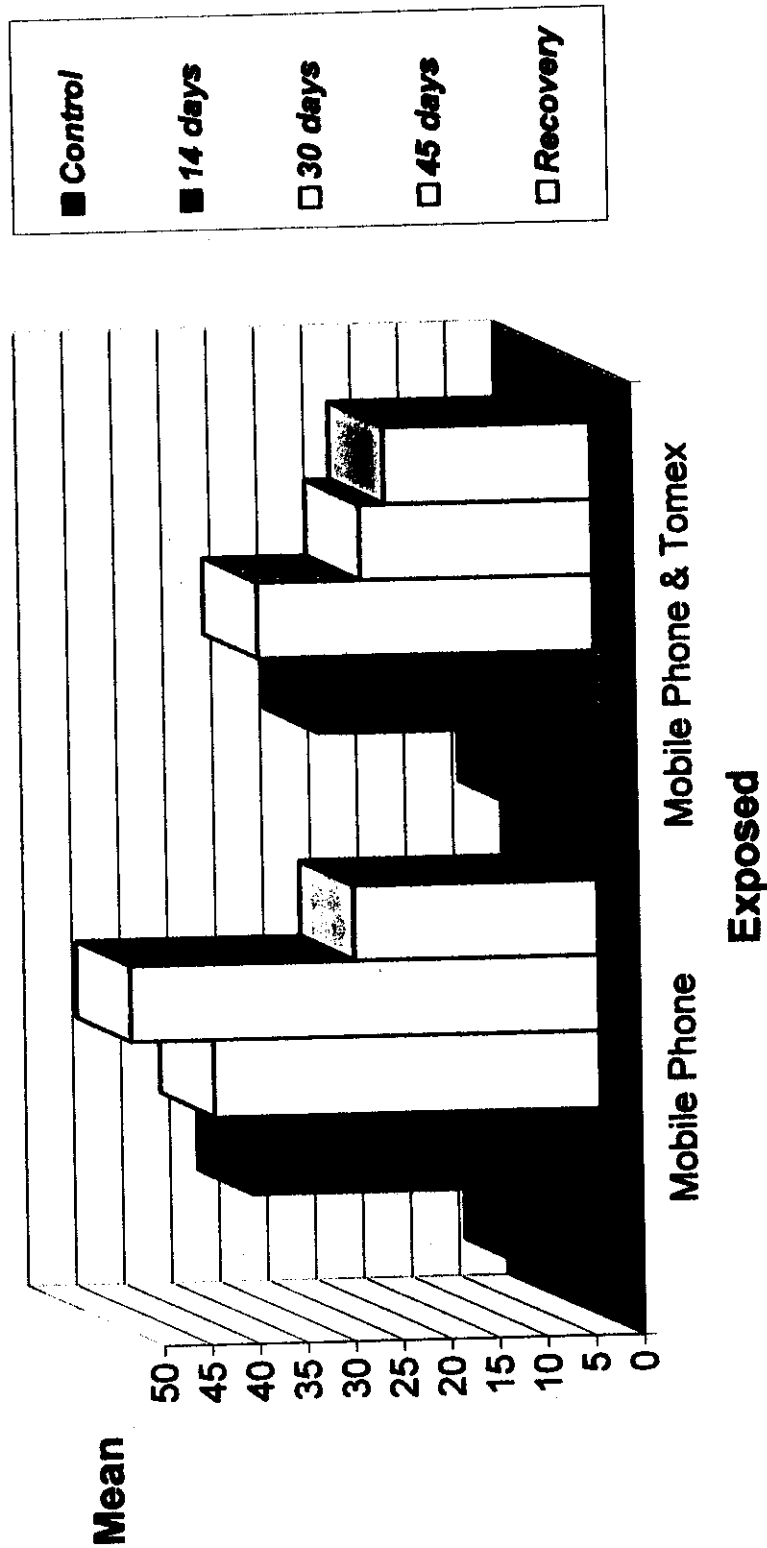


Fig.(20b): Mean values of total structural aberration observed in bone marrow cells of rats exposed to mobile phone radiation.



groups. By comparing the exposed groups with the groups, which were administrated daily with Tomex, there was a significant decrease in the mean values of all groups.

Table (11), Fig (21 a, b), show cells with one type of aberration. It was clear that, there was a significant increase in the microwave and mobile phone groups at all intervals comparing to the control group. The mean values were decreased in comparing the results between the (microwave and microwave & Tomex) groups and the (mobile and mobile phone & Tomex) groups.

Table (12), Fig (22 a, b), show that the mean values of the microwave and mobile phone exposed groups was higher than the control and there was a highly significant difference between the control and all exposed groups of animals while in the groups which were exposed to the radiation during the administration of Tomex, there was a highly significant difference after 45 days for (microwave & Tomex) groups and after 30 days for (mobile & Tomex) groups, but no significant difference was observed after these periods.

Table (11): The mean values of cells with one type of aberration in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T - Test Treated X Control	T - Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	6.40 $\pm$ 2.79			
Microwave	1) 30 days	18.80 $\pm$ 4.49	4.54**		0.009**
	2) 45 days	23.00 $\pm$ 3.39	13.29***		
	3) 60 days	22.60 $\pm$ 3.78	9.29***		
	4) R	14.80 $\pm$ 2.78	3.66*		
Microwave & Tomex	1) 30 days	12.60 $\pm$ 3.78	6.77**	1.99	0.086
	2) 45 days	18.40 $\pm$ 4.67	3.85*	1.37	
	3) 60 days	17.80 $\pm$ 2.68	15.23***	2.63*	
	4) R	17.20 $\pm$ 2.17	7.26***	0.76	
Mobile phone	1) 14 days	22.80 $\pm$ 3.49	9.38***		0.076
	2) 30 days	23.80 $\pm$ 4.27	7.19***		
	3) 45 days	21.20 $\pm$ 4.38	14.51***		
	4) R	16.80 $\pm$ 4.44	4.93**		
Mobile phone & Tomex	1) 14 days	19.60 $\pm$ 2.41	9.48***	2.58*	0.284
	2) 30 days	18.20 $\pm$ 3.35	8.07***	1.93	
	3) 45 days	16.40 $\pm$ 2.79	4.61**	1.91	
	4) R	16.60 $\pm$ 2.79	5.14**	0.07	

* Significant ($P \leq 0.05$)

** Highly significant ($P \leq 0.01$)

***Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig. (21a): The mean values of cells with one type of aberration of rats exposed to microwave radiation.

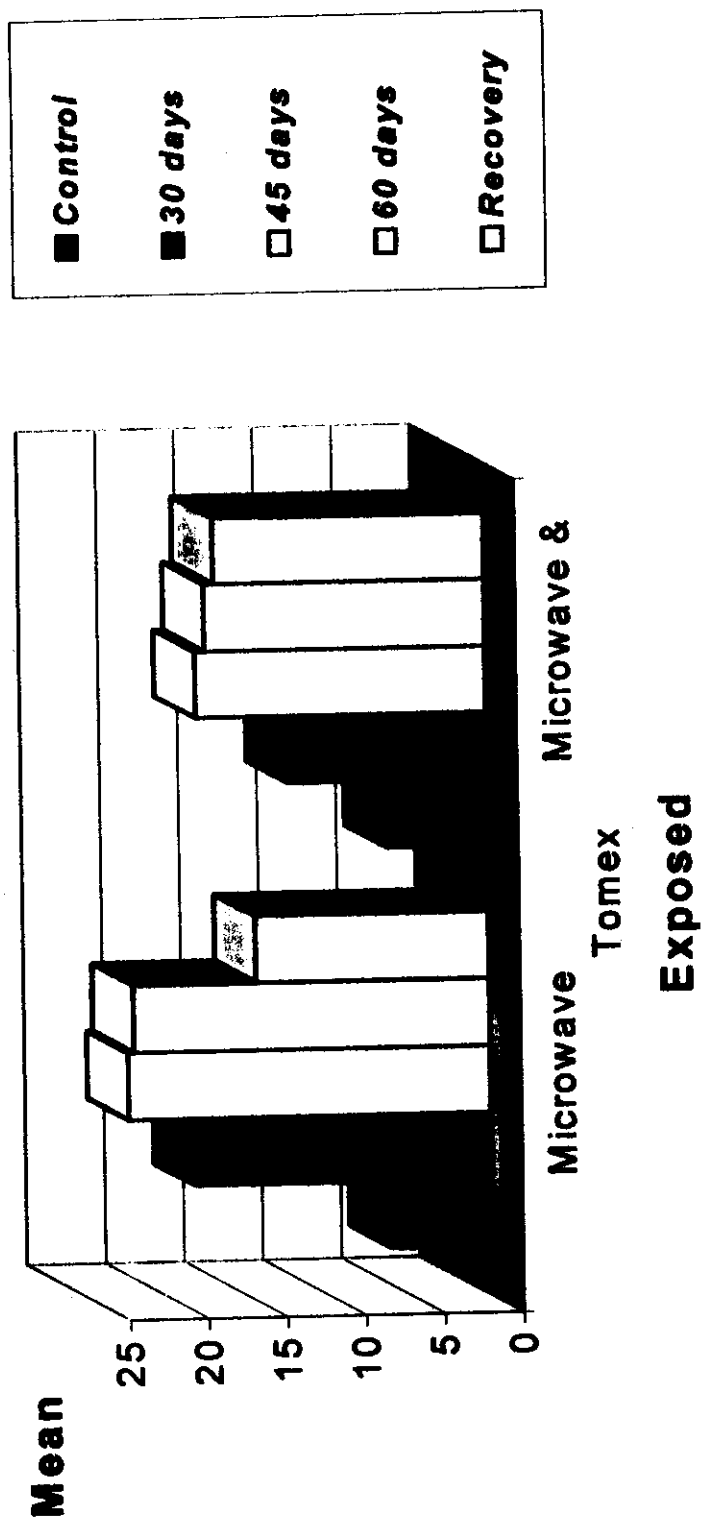


Fig. (21b): The mean values of cells with one type of aberration of rats exposed to mobile phone radiation.

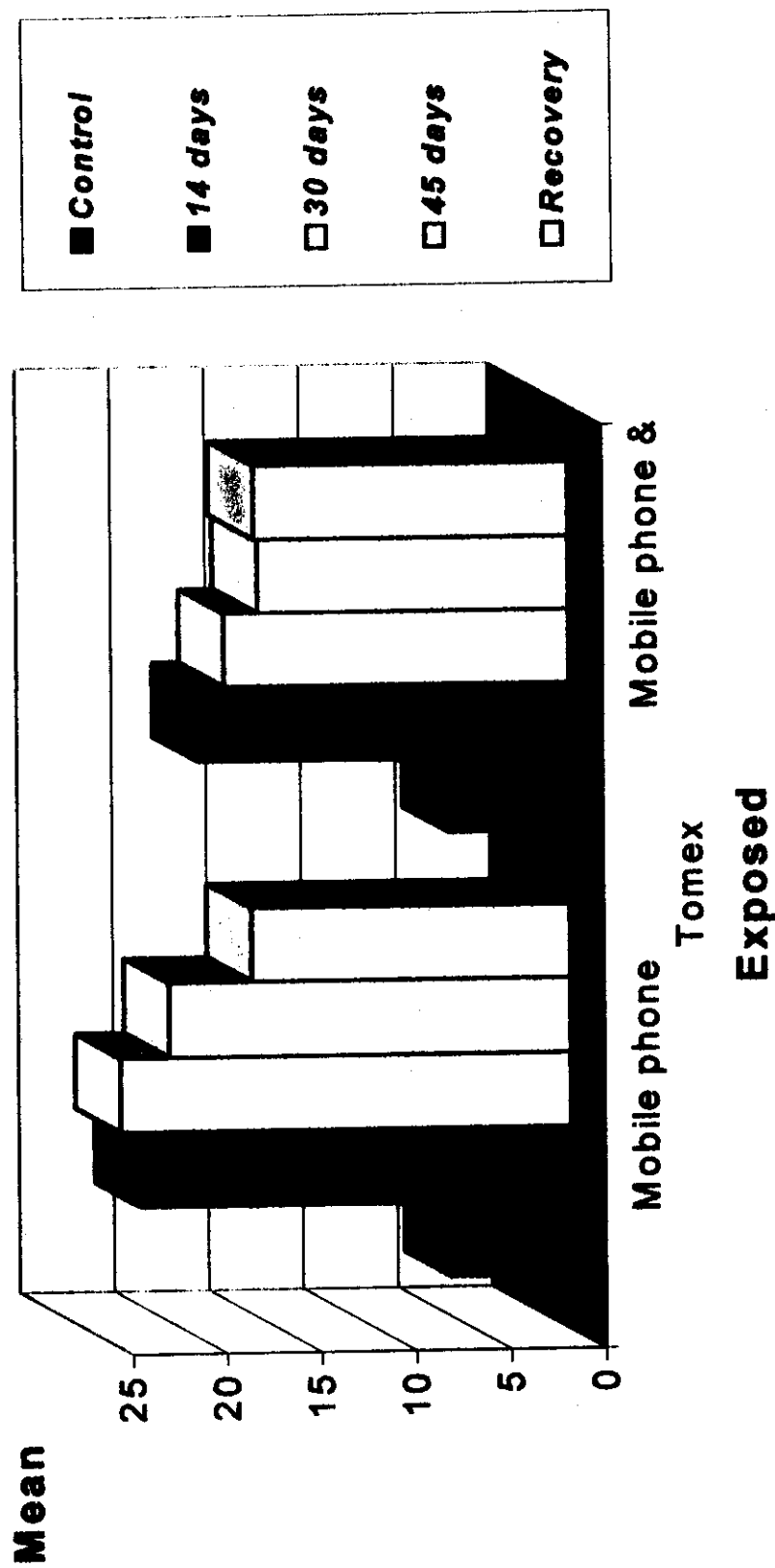


Table (12): The mean values of cells with more than one type of aberration in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Exposed	Exposure/ day	Mean $\pm$ SD	T- Test Treated X Control	T- Test for the same exposure days Radiation X Radiation & Tomex	ANOVA Test
Control	0	0.60 $\pm$ 0.55			
Microwave	1) 30 days	6.60 $\pm$ 2.41	5.26**		
	2) 45 days	10.40 $\pm$ 4.22	4.94**		
	3) 60 days	8.60 $\pm$ 1.67	9.56***		0.000***
	4) R	1.20 $\pm$ 0.84	1.50		
Microwave & Tomex	1) 30 days	1.00 $\pm$ 1.00	1.00	3.90*	
	2) 45 days	3.60 $\pm$ 1.34	4.24**	3.19*	
	3) 60 days	4.00 $\pm$ 3.14	2.01	2.77*	0.7000
	4) R	0.40 $\pm$ 0.55	0.54	2.14	
Mobile phone	1) 14 days	3.40 $\pm$ 2.07	3.81*		
	2) 30 days	4.40 $\pm$ 2.07	5.17**		
	3) 45 days	8.20 $\pm$ 3.03	5.06**		0.004**
	4) R	3.00 $\pm$ 2.83	1.76		
Mobile phone & Tomex	1) 14 days	3.40 $\pm$ 2.19	3.26*	0.00	
	2) 30 days	4.60 $\pm$ 1.82	4.78**	0.25	
	3) 45 days	1.80 $\pm$ 0.84	2.45	6.22**	0.796
	4) R	1.60 $\pm$ 1.14	1.41	0.91	

* Significant ($P \leq 0.05$)

** Highly significant ($P \leq 0.01$)

*** Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Fig.(22a): The mean values of cells with more than one type of aberration in bone marrow of cells observed in rats exposed to microwave radiation

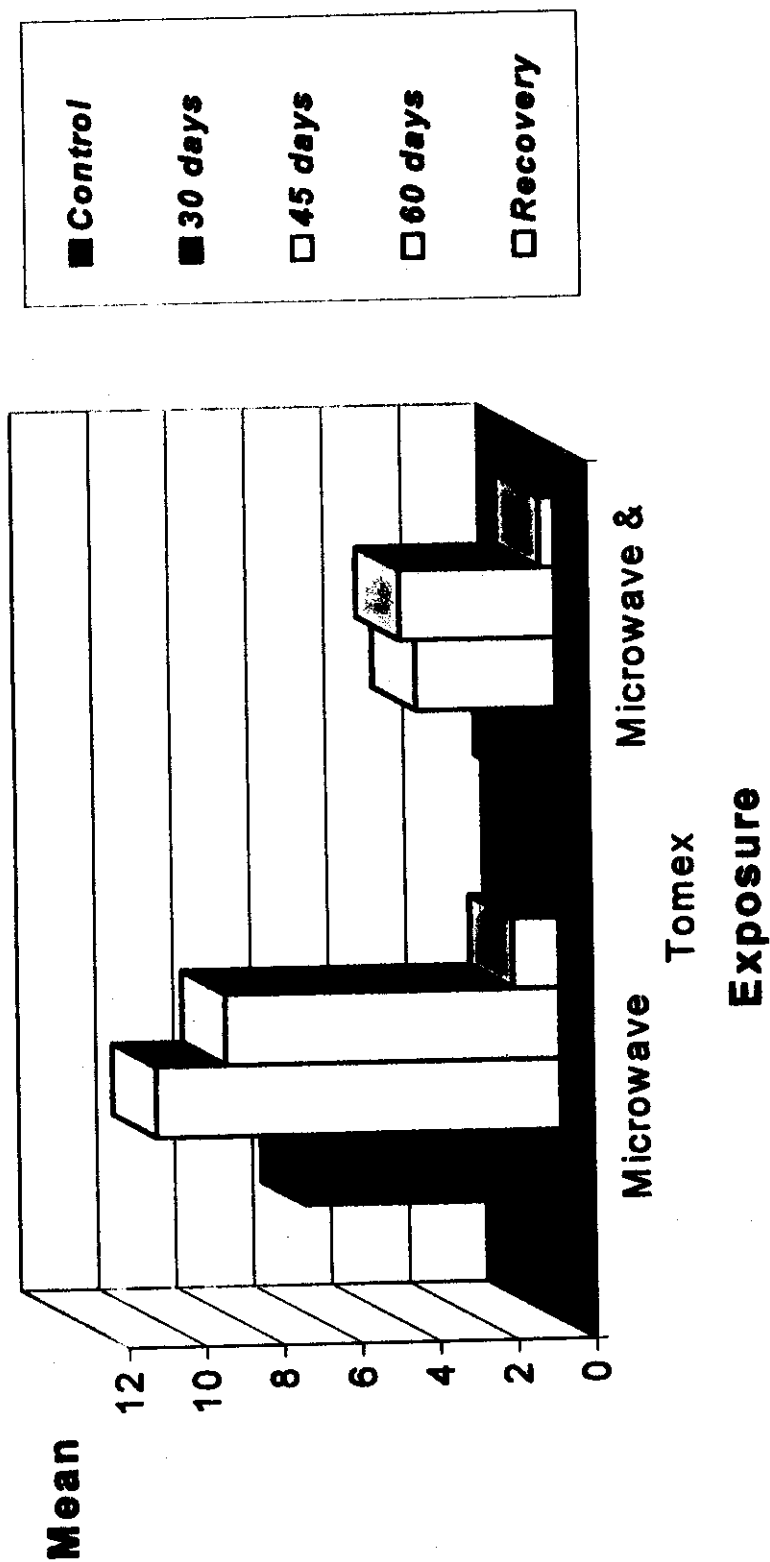


Fig.(22b): The mean values of cells with more than one type of aberration in bone marrow cells of rats exposed to mobile phone radiation.

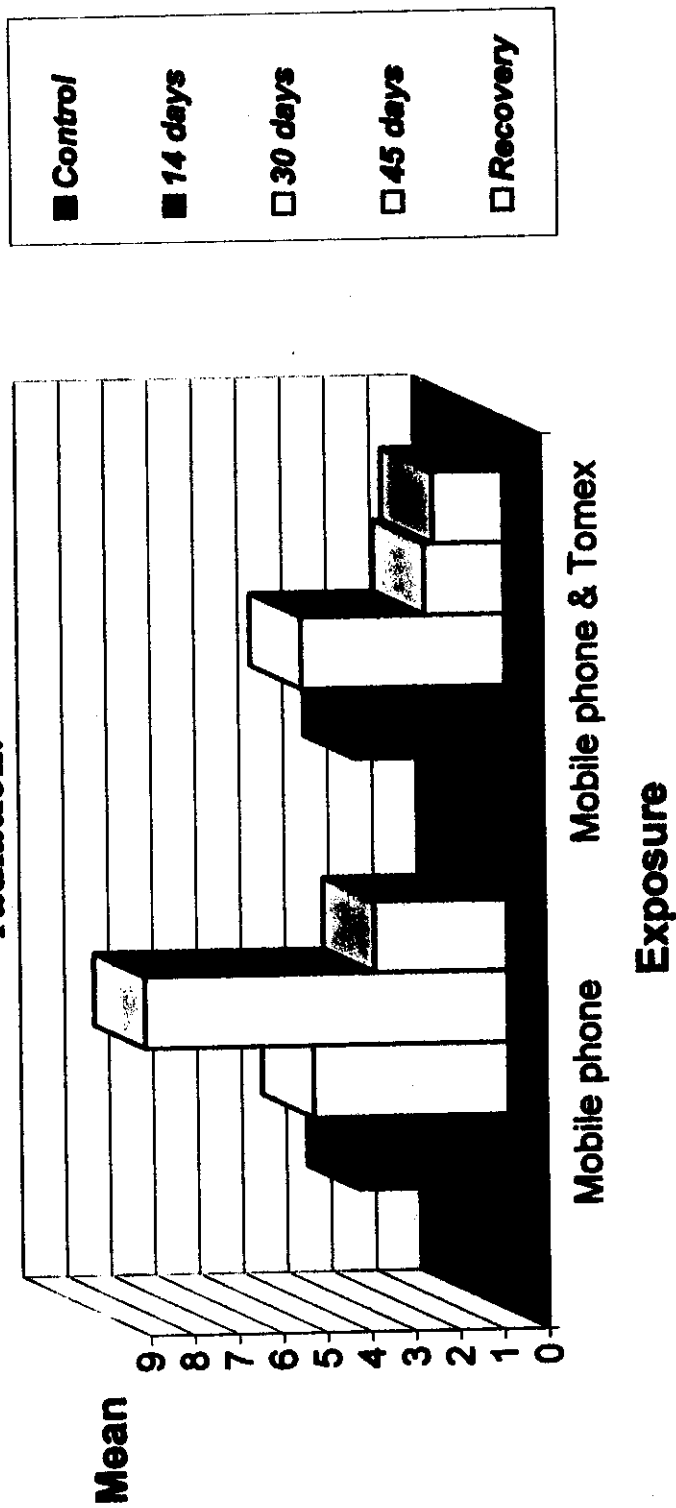


Table (13): Average of chromosomal abnormalities observed in bone marrow cells of rats exposed to microwave and mobile phone radiation.

Observation	Chromatid gaps	Deletion	Chromatid breaks	Ring	Centric fusion	Centro. Attena.	E. to E. ass.	Sticky	Stru. Aberr. %	Cells with one abnormality	Cells with abnormalities	Total
Control	1.20 ± 1.79	5.00 ± 3.46	0.80 ± 0.84	0.00 ± 0.00	1.40 ± 2.74	0.80 ± 0.84	0.60 ± 0.55	5.20 ± 1.30	1.97%	6.40 ± 2.79	0.80 ± 0.84	3.50 ± 3.60
Microwave	1) 30 days	19.80 ± 5.85**	1.60 ± 1.52	0.40 ± 0.89	1.00 ± 1.00	3.00 ± 1.00*	2.20 ± 2.68	16.00 ± 7.07*	7.97%	18.80 ± 4.49**	3.00 ± 1.00**	12.70 ± 7.27
	2) 45 days	24.80 ± 5.07**	4.20 ± 3.35	1.80 ± 1.30*	1.00 ± 1.00	4.8 ± 1.30***	2.80 ± 1.30*	10.00 ± 6.00	8.68%	23.00 ± 3.39***	4.80 ± 1.30**	16.70 ± 7.56
	3) 60 days	21.60 ± 5.94**	5.20 ± 2.17*	1.00 ± 1.23	1.20 ± 1.30	4.00 ± 0.71**	1.20 ± 1.64	9.00 ± 4.00	8.14%	22.60 ± 3.78***	4.00 ± 0.71**	15.60 ± 7.88
	4) R	12.00 ± 3.00	0.60 ± 0.55	0.00 ± 0.00	0.80 ± 0.70	0.80 ± 0.45	0.00 ± 0.00	6.00 ± 3.08	3.63%	14.80 ± 2.78*	0.80 ± 0.45	8.00 ± 7.42
Microwave & Tumor	1) 30 days	8.20 ± 2.59*	0.60 ± 0.55	0.00 ± 0.00	0.20 ± 0.45	1.80 ± 1.79	0.60 ± 0.89	7.20 ± 1.48	3.28%	12.60 ± 3.78**	1.80 ± 1.79	6.80 ± 6.65
	2) 45 days	14.60 ± 4.09*	1.20 ± 1.30	1.00 ± 1.23	1.00 ± 1.23	1.60 ± 1.34	1.20 ± 1.09	14.00 ± 8.46	6.06%	18.40 ± 4.67*	1.60 ± 1.34**	11.00 ± 8.45
	3) 60 days	13.60 ± 3.05*	0.60 ± 0.55	2.40 ± 1.34*	0.80 ± 0.84	1.20 ± 0.84	0.20 ± 0.45	6.60 ± 4.16	4.77%	17.80 ± 2.68***	1.20 ± 0.84	10.90 ± 7.81
	4) R	10.80 ± 1.92*	0.00 ± 0.00	0.40 ± 0.55	0.60 ± 1.34	1.40 ± 0.55	0.20 ± 0.45	6.40 ± 3.05	3.46%	17.20 ± 2.17***	1.40 ± 0.55	8.40 ± 8.66
Mobile Phone	1) 14 days	20.00 ± 7.25**	0.80 ± 0.84	0.20 ± 0.45	0.20 ± 0.45	5.00 ± 2.00**	2.80 ± 0.84**	5.20 ± 2.49	5.89%	22.80 ± 3.49***	5.00 ± 2.00*	13.10 ± 10.58
	2) 30 days	17.00 ± 3.16**	1.00 ± 1.00	2.00 ± 1.00**	1.2 ± 1.09*	4.00 ± 0.71**	1.80 ± 1.09	5.20 ± 3.27	6.2%	23.80 ± 4.27***	4.00 ± 0.71**	14.10 ± 10.70
	3) 45 days	22.80 ± 10.47**	3.80 ± 1.48*	1.80 ± 1.09*	1.40 ± 1.34	2.00 ± 2.35	1.20 ± 2.17	10.40 ± 5.59	8.2%	21.20 ± 4.38***	2.00 ± 2.35**	14.70 ± 7.72
	4) R	13.20 ± 5.89**	0.60 ± 0.55	0.80 ± 0.84	0.40 ± 0.55	2.00 ± 0.71	0.80 ± 1.30	9.20 ± 4.15	4.83%	16.80 ± 4.44**	2.00 ± 0.71	9.90 ± 8.08
Mobile phone & Tumor	1) 14 days	11.60 ± 3.58	0.60 ± 0.55	1.60 ± 1.52	1.40 ± 1.14	0.80 ± 0.84	1.40 ± 1.14	4.80 ± 3.77	4.57%	19.60 ± 2.41***	0.80 ± 0.84*	11.50 ± 8.81
	2) 30 days	19.80 ± 9.20*	1.80 ± 0.84	0.60 ± 0.89	0.80 ± 0.84	0.20 ± 0.20	1.60 ± 0.55*	11.80 ± 14.89	6.6%	18.20 ± 3.35***	0.20 ± 0.20**	11.40 ± 7.60
	3) 45 days	13.80 ± 5.81*	1.00 ± 1.00	0.00 ± 0.00	0.00 ± 0.00	0.80 ± 0.58	0.60 ± 0.89	9.20 ± 4.15	4.23%	16.40 ± 2.79**	0.80 ± 0.58	9.10 ± 7.94
	4) R	10.80 ± 4.09	0.40 ± 0.89	0.00 ± 0.00	0.40 ± 0.55	0.60 ± 0.40	0.60 ± 0.55	8.60 ± 4.62	4.31%	16.60 ± 2.79**	0.60 ± 0.40	9.10 ± 8.16

*Significant ($P \leq 0.05$)**Highly significant ($P \leq 0.01$)***Very highly significant ($P \leq 0.001$)

R = Recovery (30 days after post exposure)

Electrophoretic studies of proteins:

SDS polyacrylamide gel electrophoresis (PAGE) of proteins extracted from liver of rats showed that, the total number of polypeptides in the liver of unexposed rats (control) was 7 bands. The polypeptides were increased to 13, 15 and 14 bands in the liver of rats exposed to 9865 MHz for 30, 45, 60 days, respectively, (Table 14) (Fig. 23, 24). By recovery for 30 days, the liver of rats showed decline of the proteinogram to 10 bands. In control rats, the most proteins presented in the liver had molecular weight of 86, 66, 34, 32.5, 30, 26 and 23 kilo Dalton (kDa). Exposure of rats to 9865 MHz for 30 days revealed new synthesized polypeptides with molecular weight of 107, 87.5, 69.8, 53, 50, 43.8, 39.6, 37, 33, 31.5, 29.5, 25 and 21 kDa comparing to the control. By increasing the time of exposure to 45 days, the number of bands increased to 15 bands and also new types of synthesized proteins with molecular weight of 126, 88, 78, 75, 70.7, 54, 52, 38, 34, 32, 30 and 22 kDa appeared. After 60 days of the exposure to microwave radiation more bands appeared with molecular weight of 146, 112, 72, 65, 56.5, 40.7, 29 and 26 kDa. In the recovery group (30 days after post-exposure) some bands disappeared with molecular weight 146, 112, 89, 72, 65, 56.5, 40.7, 38.7, 34.6, 32 and 30.6 kDa and a new bands were observed with molecular weight of 104, 87, 71, 69, 66.7, 54 and 37 kDa, while other polypeptide bands remained stable with molecular weight 87, 66.7, 29.7 and 26.5 kDa.

Exposure of rats to microwave radiation together with Tomex for 30, 45 and 60 days showed a variety of the total number of protein bands to 11, 13 and 12 bands respectively, (Table 15, Fig. 25, 26). Also the liver of rats, which were recovered for 30 days after the last exposure revealed 11 polypeptide bands only. After 30 days of exposure to 9865 MHz microwave radiation together with Tomex, new bands with molecular weight of 109, 87, 71, 69, 53, 37, 27, 25 and 21 kDa were appeared

Table (14): SDS-PAGE banding pattern of proteins measured in liver cells of rats exposed to microwave radiation.

M.Wt KDa	Protein	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5
Band No.	Marker	(Control)	(30 days)	(45 days)	(60 days)	(Recovery)
1	205					
2					146	
3				126		
4	119					
5					112	
6			107	107		
7						104
8	98					
9					89	
10				88		
11			87.5			87
12		86				
13				78		
14				75		
15					72	
16						71
17				70.7		
18			69.8			69
19		66				66.7
20					65	
21					56.5	
22				54		54
23			53			
24	52.3			52		
25			50			
26			43.8			
27					40.7	
28			39.6	39.8		
29				38	38.7	
30			37			37
31	36.8					
32		34		34	34.6	
33			33			
34		32.5		32	32	
35			31.5			
36	30.1	30		30	30.6	
37			29.5		29	29.7
38		26			26	26.5
39			25	25.6		
40		23				
41	22			22	22.6	22
42			21			
No. of Fractions	7	7	13	15	14	10

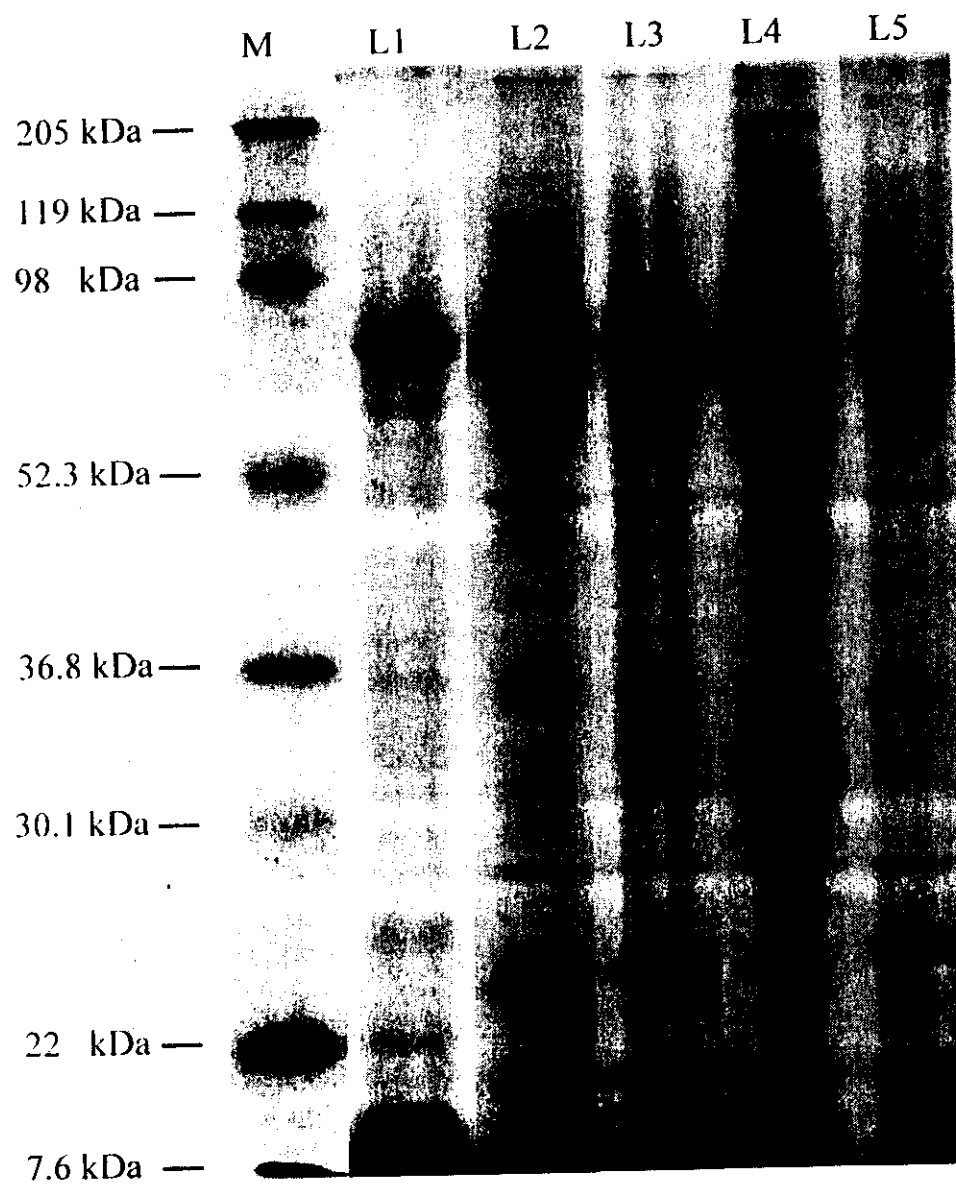


Fig (23): SDS-15% polyacrylamide gel electrophoresis of liver proteins extracted from rats exposed to microwave radiation. L: Lane, M: Protein molecular weight marker, L1: Control, L2: 30 days, L3: 45 days, L4: 60 days, L5: Recovery

**Fig.(24):Banding pattern of proteins measured in liver cells of rats
exposed to microwave radiation.**

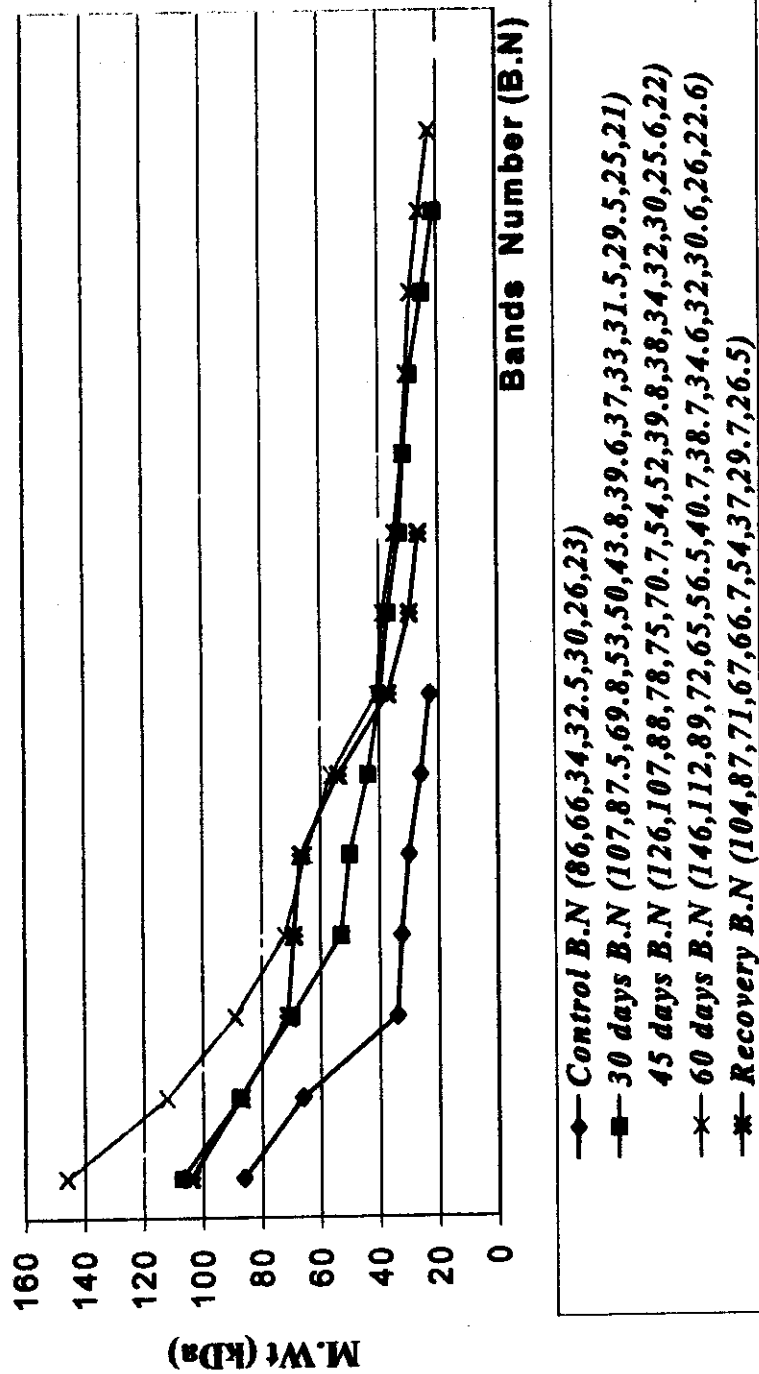


Table (15): SDS-PAGE banding pattern of proteins measured in liver cells of rats exposed to microwave & Tomex.

M.Wt KDa	Protein	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5
Band No.	Marker	(Control)	(30 days)	(45 days)	(60 days)	(Recovery)
1	205					
2				157		
3				136		
4	119					
5				111		
6			109			
7						104
8						99
9	98					
10					89	
11				88		
12			87			
13		86				86
14				73	73	
15			71		71	71
16				70		
17			69			
18						67
19		66				
20					55	
21				54		
22			53			53
23	52.3				52.8	
24				39	39.7	
25			37		37	37
26	36.8			36		
27						35
28		34	34		34	
29				33		
30		32.5				
31					31	
32	30.1	30	30	30		30
33					29	
34			27			
35		26				26
36			25	25	25	
37		23				
38	22					22
39			21			
40				18	18	
No. of Fractions	7	7	11	13	12	11

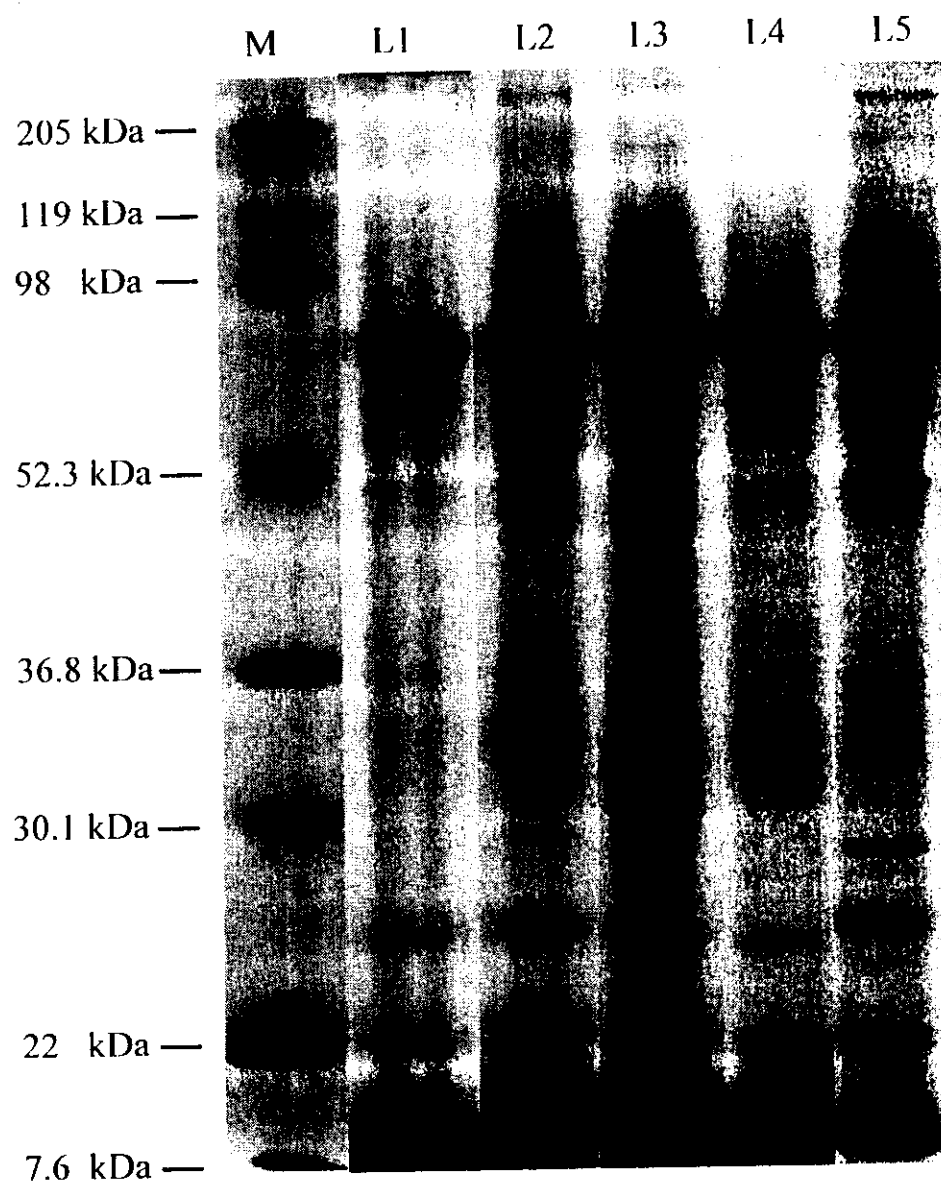
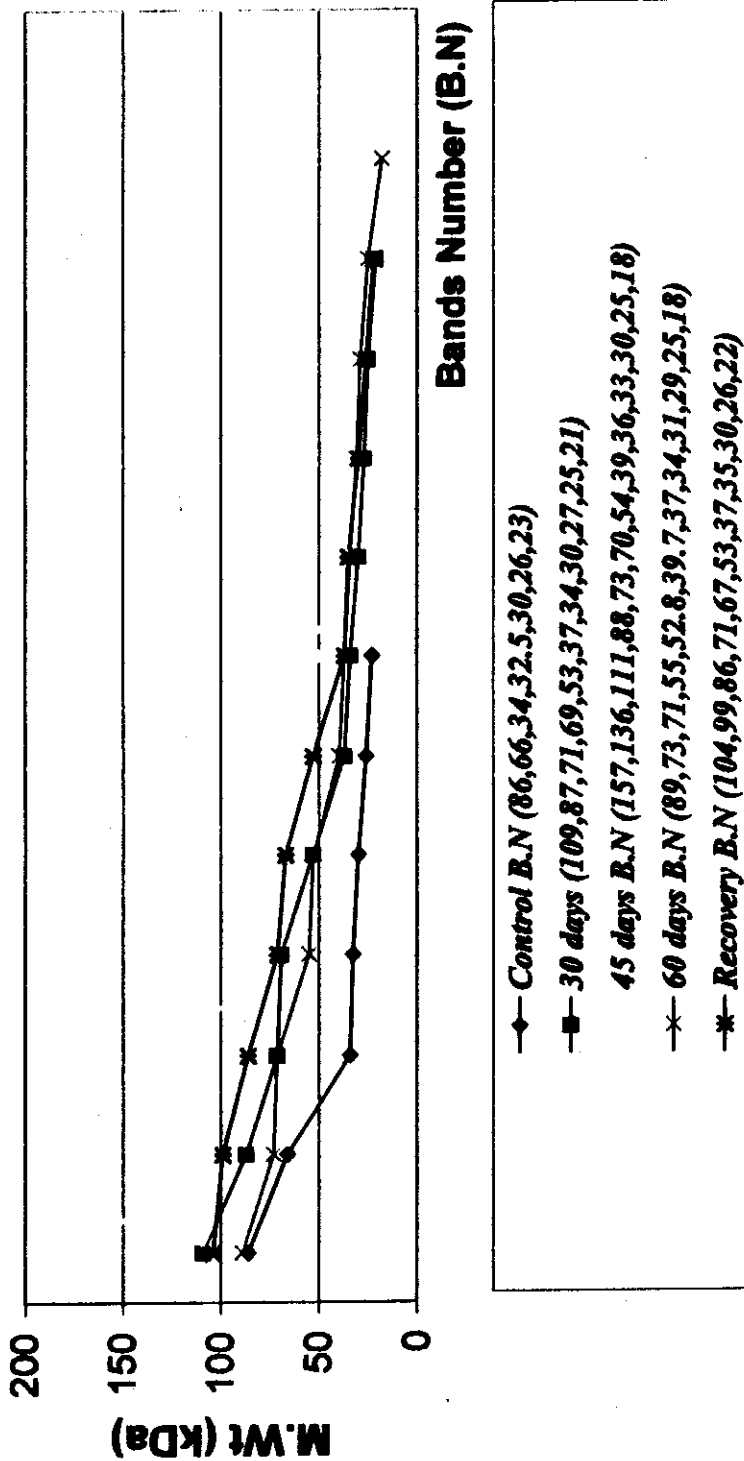


Fig (25): SDS-15% polyacrylamide gel electrophoresis of liver proteins extracted from rats exposed to microwave radiation and were given 0.1 ml Tomex. L: Lane, M: Protein molecular weight marker, L1: Control, L2: 30 days, L3: 45 days, L4: 60 days, L5: Recovery

Fig. (26): Banding pattern of proteins measured in liver of rats exposed to microwave & Tomex.



comparing to unexposed rats. With increasing the exposure time to 45 days other bands appeared with molecular weight of 157, 136, 111, 88, 73, 70, 54, 39, 36, 33 and 18 kDa. After 60 days of exposure the number of polypeptide bands decreased again and some bands disappeared as bands with MW of 157, 136, 111, 70, 54, 36, 33 and 30 kDa. In the recovery group new bands appeared with molecular weight of 104, 99, 86, 67, 53, 35, 30, 26 and 22 kDa (Table 15) (Fig. 25, 26).

In the current study, data of the electrophoretic pattern of proteins was observed in the liver of rats exposed to mobile phone with 900 MHz for 14, 30, 45 days (Table 16) (Fig. 27, 28). The total number of bands in the exposed animals was 13, 11 and 13 respectively. After 30 days of the post exposure (recovery group), the liver rats showed decline of the proteinogram to 10 bands. After 14 days of the exposure, new polypeptide fractions appeared with molecular weight of 132, 97, 70, 67, 64, 38, 36, 33, 31, 29, 25 and 20 kDa, these bands were not present in the unexposed group. After 30 days of exposure the number of bands were decreased and new bands appeared with MW 69, 50 and 32 kDa, while the disappeared bands were with MW of 132, 97, 64 and 29 kDa. By increasing the time of exposure to 45 days the number of bands increased again and new polypeptides appeared with molecular weight 132, 120, 98, 67, 39 and 29 kDa. In the recovery group (30 days after the last exposure) the number of bands decreased to 10 bands and new polypeptide fractions appeared with molecular weight 104, 99, 65, 53, 34, 26 and 22 kDa.

In the present study, protein polymorphism was screened in rats liver exposed to mobile phone radiation with 900 MHz in a combination with the uptake of 0.1ml Tomex for 14, 30 and 45 days. Data showed that the number of polypeptides of exposed rats was 10, 10 and 9 respectively, while the number of bands in the recovery group (30 days after the last exposure) was increased to 14 bands (Table 17) (Fig. 29, 30). The control

group had 7 bands with molecular weight of 86, 66, 34, 32.5, 30, 26 and 23 kDa. After 14 days of exposure and with the effect of Tomex the number of bands increased and many new bands appeared as 104, 88.8, 78, 71, 55, 52 and 38 kDa. By increasing the time of exposure to 30 days, two bands disappeared with MW of 78, 52 kDa, while another two bands appeared with MW of 32 and 30 kDa. After 45 days there was no notable change from the previous period except the disappearance of a two bands with MW of 37 and 30 kDa and the appearance of new band with MW 35 KDa. After 30 days of the last exposure time, new bands appeared with MW of 85, 67, 53, 48, 44 and 42, 39, 37, 33, 30 and 26.6 kDa while others disappeared as 87, 72, 55, 35 and 27 kDa (Table 17).

Table (16): SDS-PAGE banding pattern of proteins measured in liver cells of rats exposed to mobile phone radiation.

M.Wt (KDa)	Protein	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5
Band No.	Marker	(Control)	(14 days)	(30 days)	(45 days)	(Recovery)
1	205					
2			132		132	
3					120	
4	119					
5						104
6						99
7	98				98	
8			97			
9		86	86	86	86	86.6
10			70	70	70.7	
11				69		
12			67		67	
13		66				
14						65
15			64			
16						53
17	52.3					
18				50		
19					39	
20			38	38		
21						37
22	36.8		36	36	36.7	
23		34				34
24			33	33	33	
25		32.5		32		
26			31	31	31	31
27	30.1	30				
28			29		29	
29		26				26
30			25	25	25	
31		23				
32	22					22
33			20	20	20	
No. of Fractions	7	7	13	11	13	10

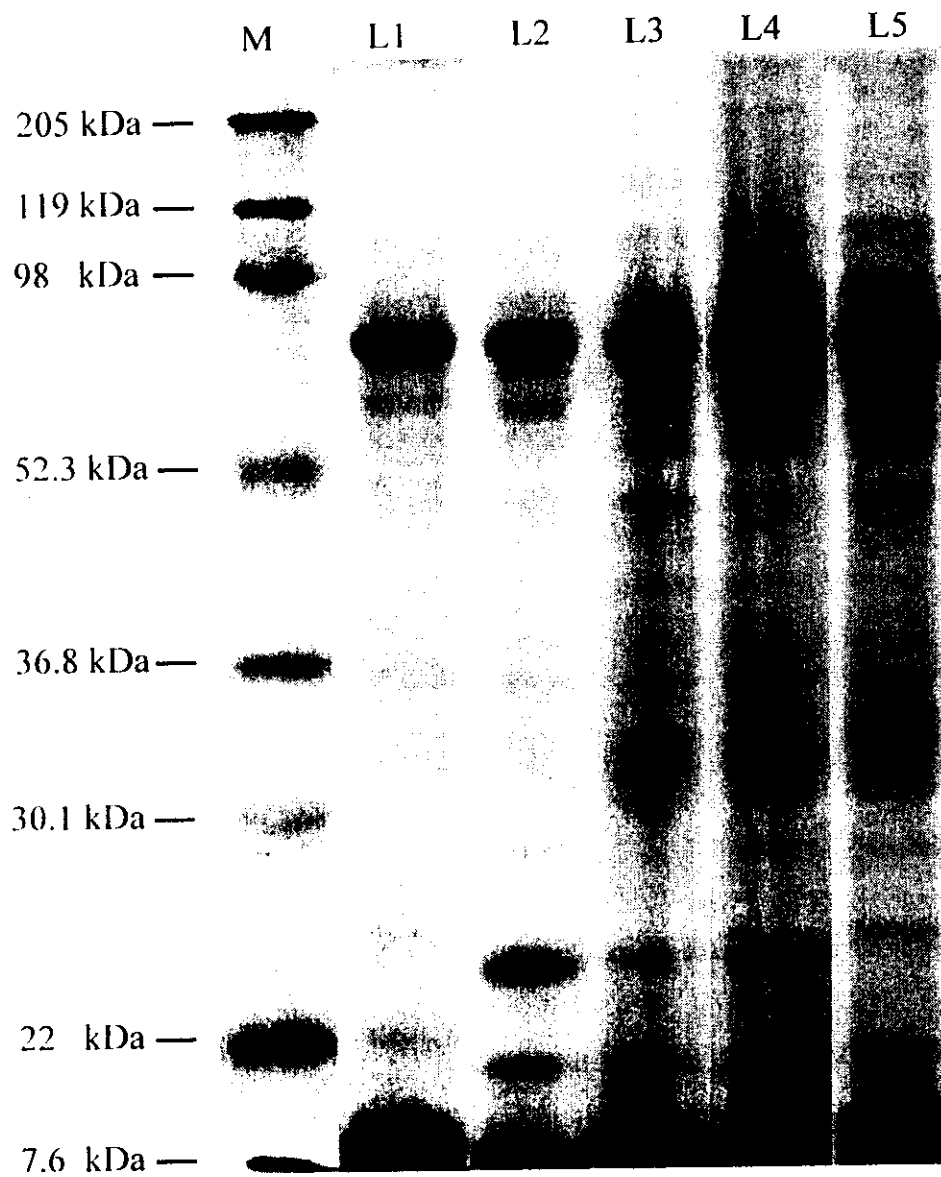


Fig (27): SDS-15% polyacrylamide gel electrophoresis of liver proteins extracted from rats exposed to mobile phone radiation. L: Lane, M: Protein molecular weight marker, L1: Control, L2: 14 days, L3: 30 days, L4: 45 days, L5: Recovery

Fig.(28): Banding pattern of proteins measured in liver of rats exposed to mobile phone radiation.

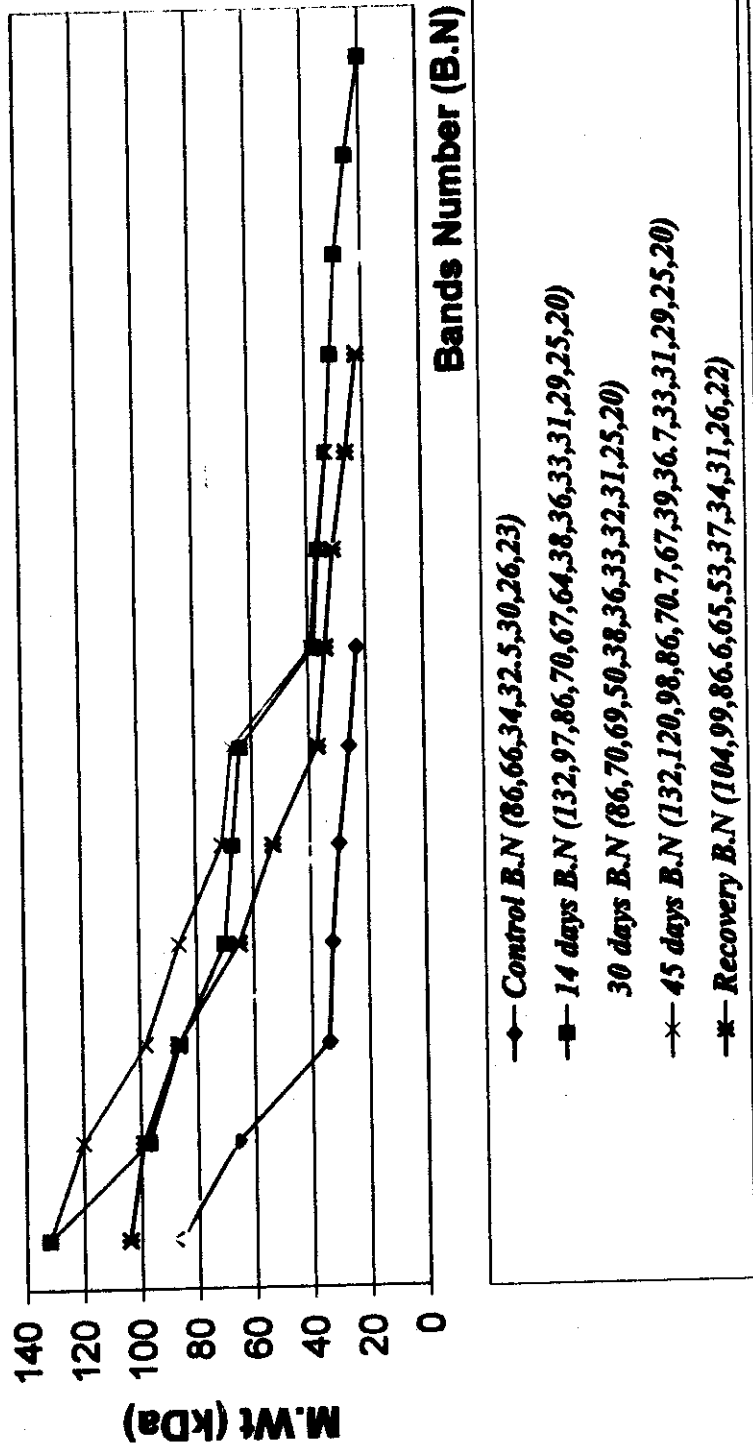


Table (17): SDS-PAGE banding pattern of proteins measured in liver cells of rats exposed to mobile phone & Tomex.

M.Wt (KDa) Band No.	Protein Marker	Lane 1 (Control)	Lane 2 (14 days)	Lane 3 (30 days)	Lane 4 (45 days)	Lane 5 (Recovery)
1	205					
2			104	104	104	
3	119					
4	98					
5			88.8	88		
6					87	
7		86				
8						85
9			78			
10					72	
11			71	71.5		
12						67
13		66				
14			55	55	55	
15						53
16	52.3		52			
17						48
18						44
19						42
20						39
21			38			
22				37		37
23	36.8					
24					35	
25		34	34.7	34	34	34.8
26						33
27		32.5		32	32	32
28	30.1	30		30		30
29				27	27	
30		26	26.8			26.6
31		23	23	23	23	23
32	22					
No. of Fractions	7	7	10	10	9	14

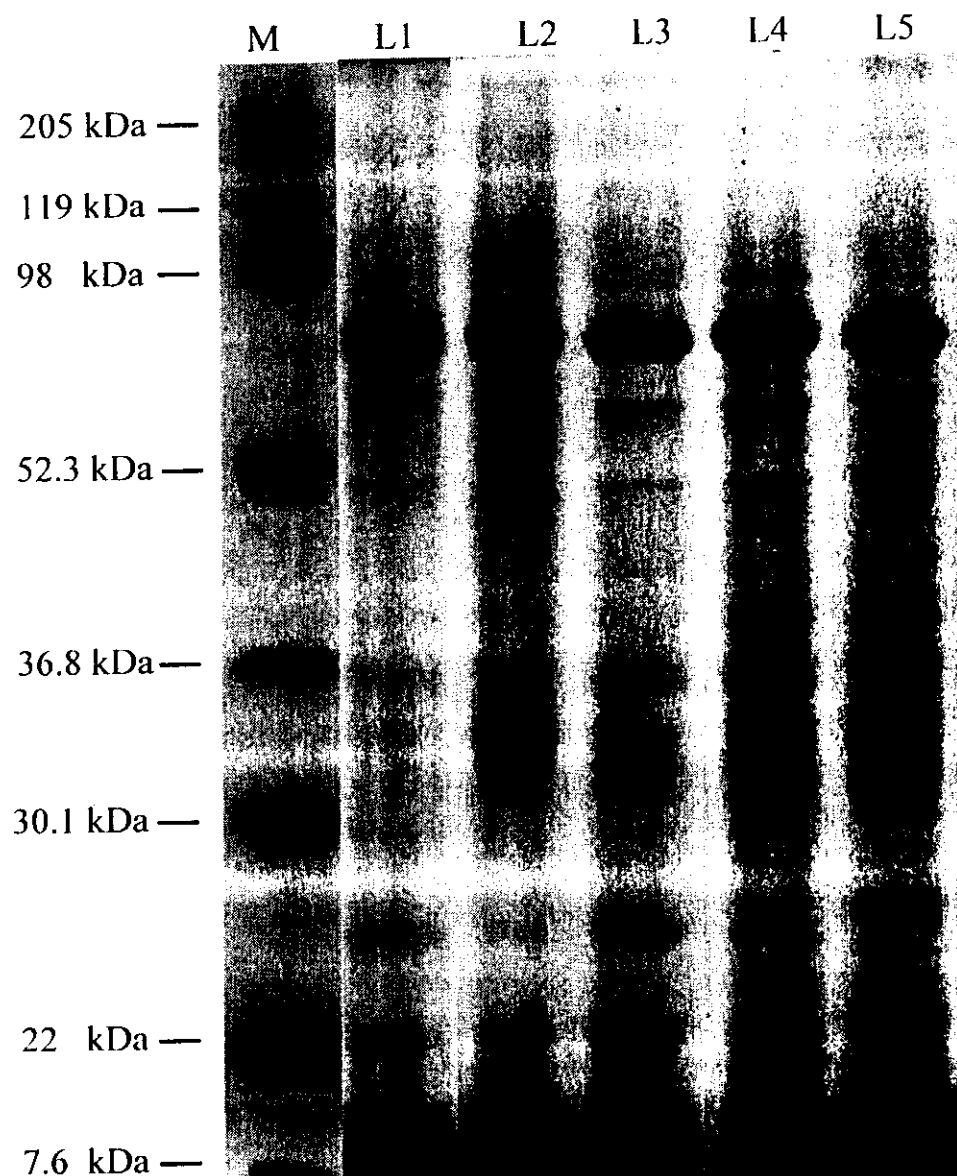
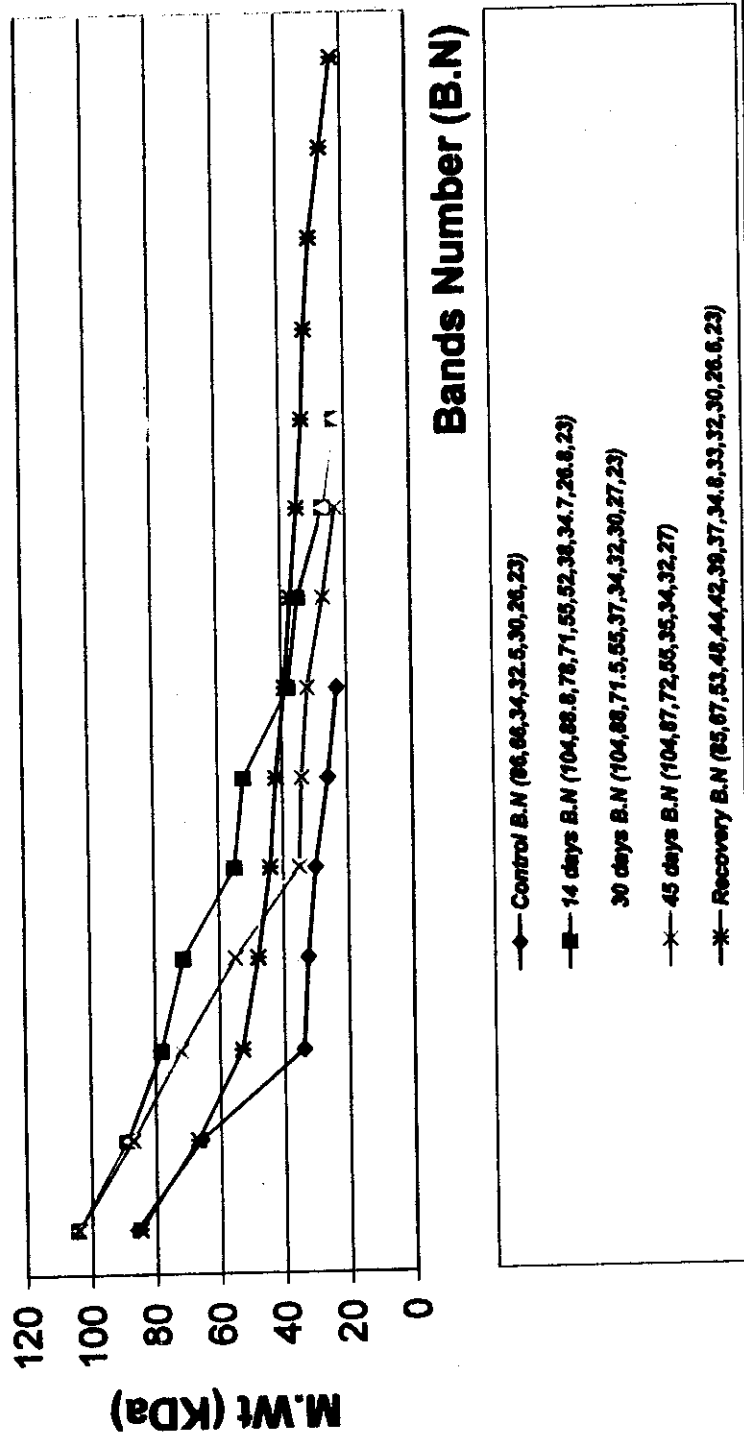


Fig (29): SDS-15% polyacrylamide gel electrophoresis of liver proteins extracted from rats exposed to mobile phone radiation and were given 0.1 ml Tomex. L: Lane, M: Protein molecular weight marker, L1: Control, L2: 14 days, L3: 30 days, L4: 45 days, L5: Recovery

Fig. (30): Banding pattern of protein measured in liver of rats exposed to mobile phone radiation & Tomex



Also, the present study, (Table 18), (Fig. 31, 32), showed the electrophoretic pattern of proteins measured in the brain of rats exposed to 9865 MHz microwave radiation for 30, 45 and 60 days. The total number of fractions in the nonexposed rats was 11 bands with molecular weight of 64, 49.9, 40.9, 37.4, 31.7, 30, 27, 25.7, 23.8, 22 and 18 kDa, this number was changed to 14, 10 and 10 with increasing the time of exposure to 30, 45 and 60 days respectively (Table 18). After 30 days of the post exposure (recovery group) the polypeptides bands were decreased to 9 bands. After 30 days of exposure to microwave radiation new polypeptide bands appeared with molecular weight of 190, 148.3, 96.2, 70.3, 36.6, 26.9, 20.5, and 15.6 kDa comparing to the control. With increasing the time of exposure to 45 days, new bands appeared as 151.7, 99, 92, 72.9, 66.5, 50.8, 42.3, 37.9 and 32 kDa and other polypeptide bands disappeared as 190, 148, 96, 70, 64, 49, 40, 25, 23, 20, and 15 kDa. After 60 days of exposure some protein fractions disappeared with molecular weight 151.7, 99, 92 66.5, 50.8 and 37 kDa and others were observed as 155.3, 100, 38.6 and 27.6 kDa. The number of bands in the recovery group was decreased to 9 bands where new proteins were disappeared with molecular weight 155, 100, 72, 67.7 and 51.6 kDa and others appeared with molecular weight of 50.8, 23.9, 22.5 and 16.7 kDa.

Protein polymorphism in the brain of rats exposed to microwave radiation and administrated with Tomex for 30, 45 and 60 days showed a variety of the total number of bands. It recorded 7, 11 and 10 bands respectively, in dependence to the exposure time (Table 19), (Fig. 33, 34). The number of bands in the recovery group was 13 bands. After 30 days of exposure to 9865 MHz microwave radiation together with the influence of Tomex, new polypeptide bands with molecular weight of 155, 99, 67, 51, 42.5, 38 and 32 kDa were appeared comparing to the unexposed group. By

Table (18): SDS-PAGE banding pattern of protein measured in brain of rats exposed to microwave radiation.

M.Wt (KDa)	Protein	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5
Band No.	Marker	(Control)	(30 days)	(45 days)	(60 days)	(Recovery)
1	205					
2			190.2			
3					155.3	
4				151.7		
5			148.3			
6	119					
7					100.6	
8				99		
9	98					
10			96.2			
11				92.2		
12				72.9	72.5	
13			70.3			
14					67.7	
15				66.5		
16		64.1	64.5			
17	52.3					
18					51.6	
19				50.8		50.8
20		49.9	49.4			
21				42.3	42.9	42.2
22		40.9	40.8			
23					38.6	38.1
24		37.4		37.9		
25	36.8		36.6			
26				32.14	32.5	32
27		31.7	31.4			
28	30.1	30.2				
29		27.4			27.6	27.7
30			26.9	26	26	26.1
31		25.7	25.5			
32		23.8	23.1			23.9
33	22	22.2				22.5
34			20.5			
35		18.2				
36						16.7
37			15.6			
No. of Fractions	7	11	14	10	10	9

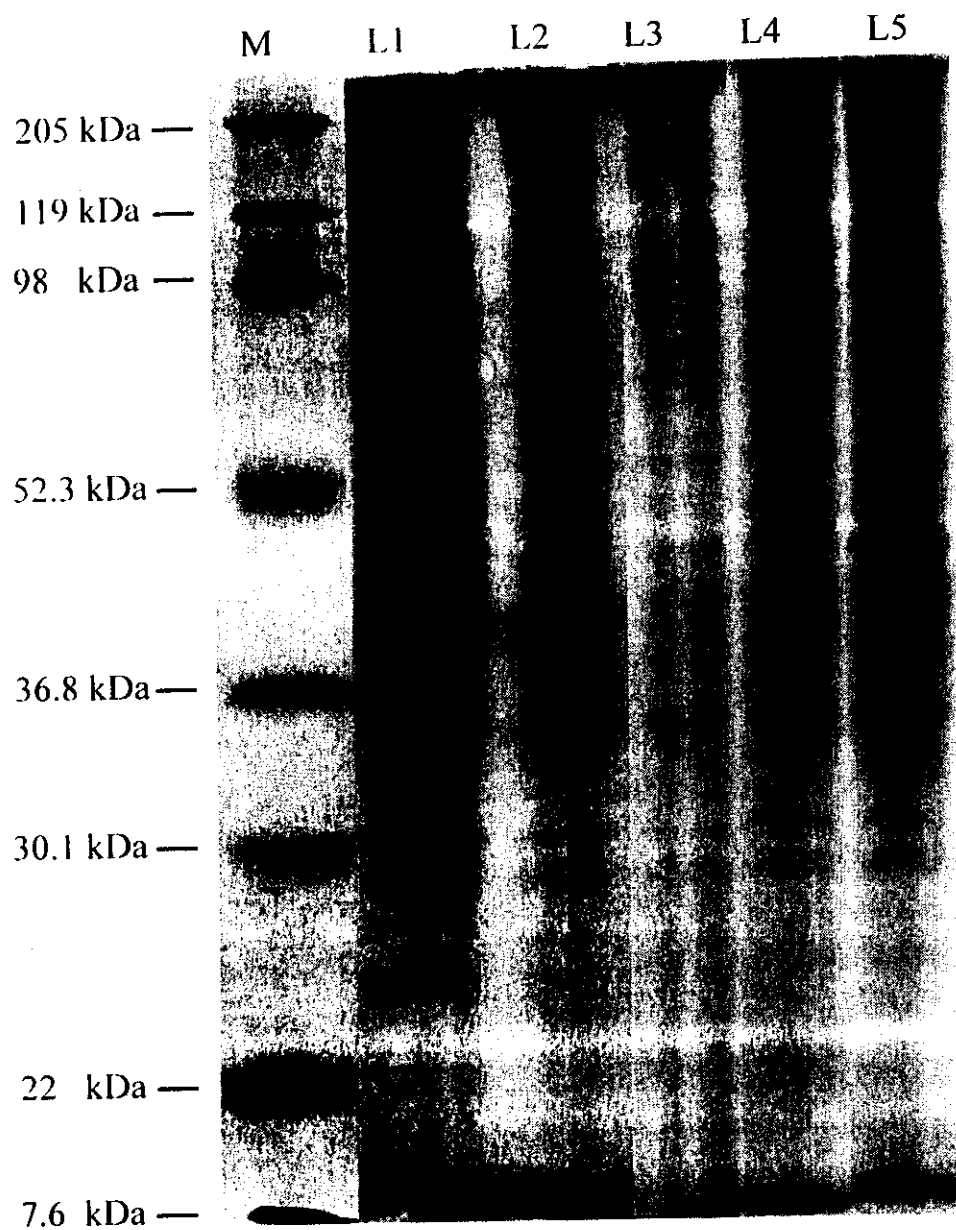


Fig (31): SDS-15% polyacrylamide gel electrophoresis of brain proteins extracted from rats exposed to microwave radiation. L: Lane, M: Protein molecular weight marker, L1: Control, L2: 30 days, L3: 45 days, L4: 60 days, L5: Recovery

Fig. (32): Banding pattern of proteins measured in brain cells of rats exposed to microwave radiation.

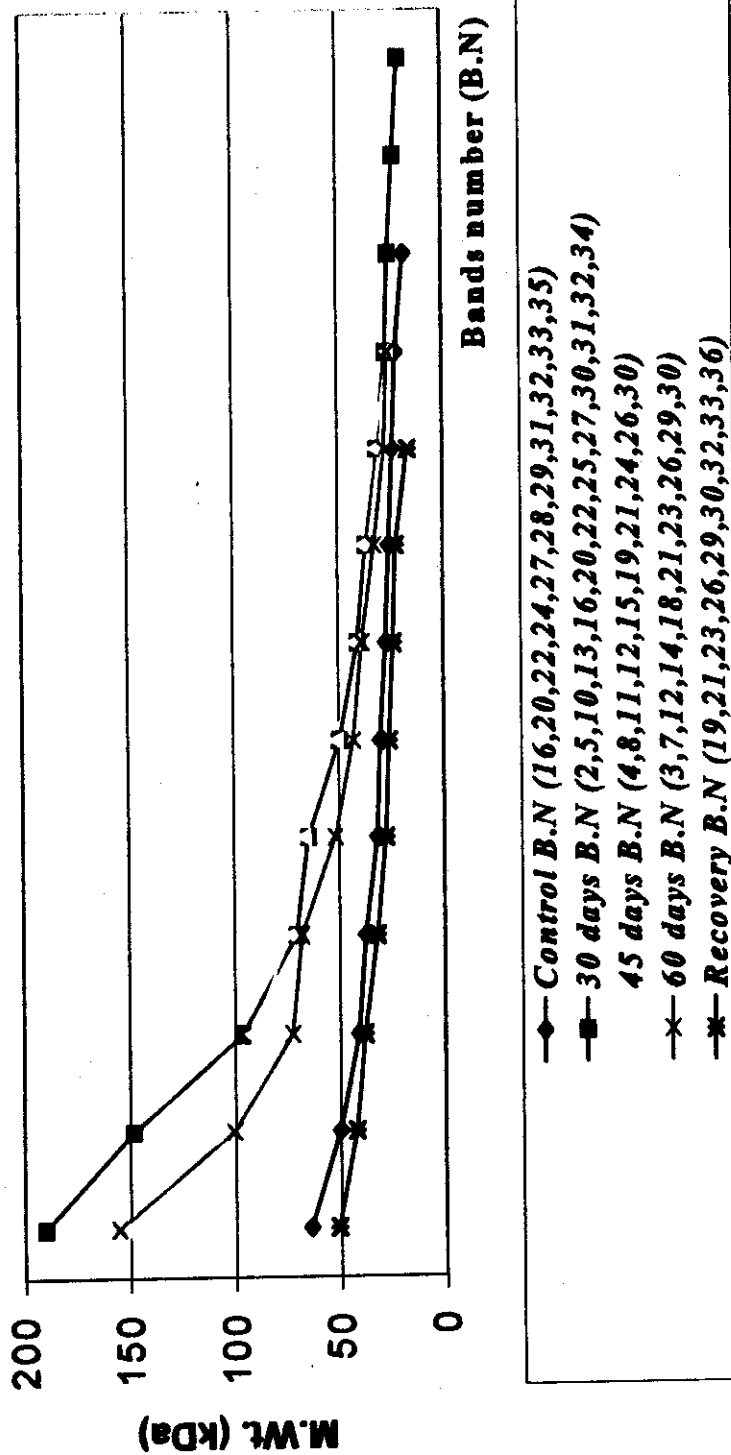


Table (19): SDS-PAGE banding pattern of proteins measured in brain cells of rats exposed to microwave & Tomex.

M.Wt (KDa) Band No.	Protein	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5
	Marker	(Control)	(30 days)	(45 days)	(60 days)	(Recovery)
1	205					
2						189
3			155	155.3	155.3	
4	119					
5						101.9
6			99	99		
7	98					
8						78
9					72	
10						71.6
11			67	66.9	66.9	
12		64				
13						58.8
14	52.3					
15			51	50.8	50.8	
16		49.9				
17						47
18			42.5			42.8
19				41.7	41.9	
20		40.9				
21			38			
22		37		37.5	37.8	
23	36.8					
24						35.2
25						33.2
26			32			
27		31.7		31.7	31.9	
28	30.1	30				30
29						28.5
30		27.4		27	27	
31		25.7		25.5	25.6	25.8
32						24
33		23.8		23	23	
34	22	22		22		
35		18				
No. of Fractions	7	11	7	11	10	13

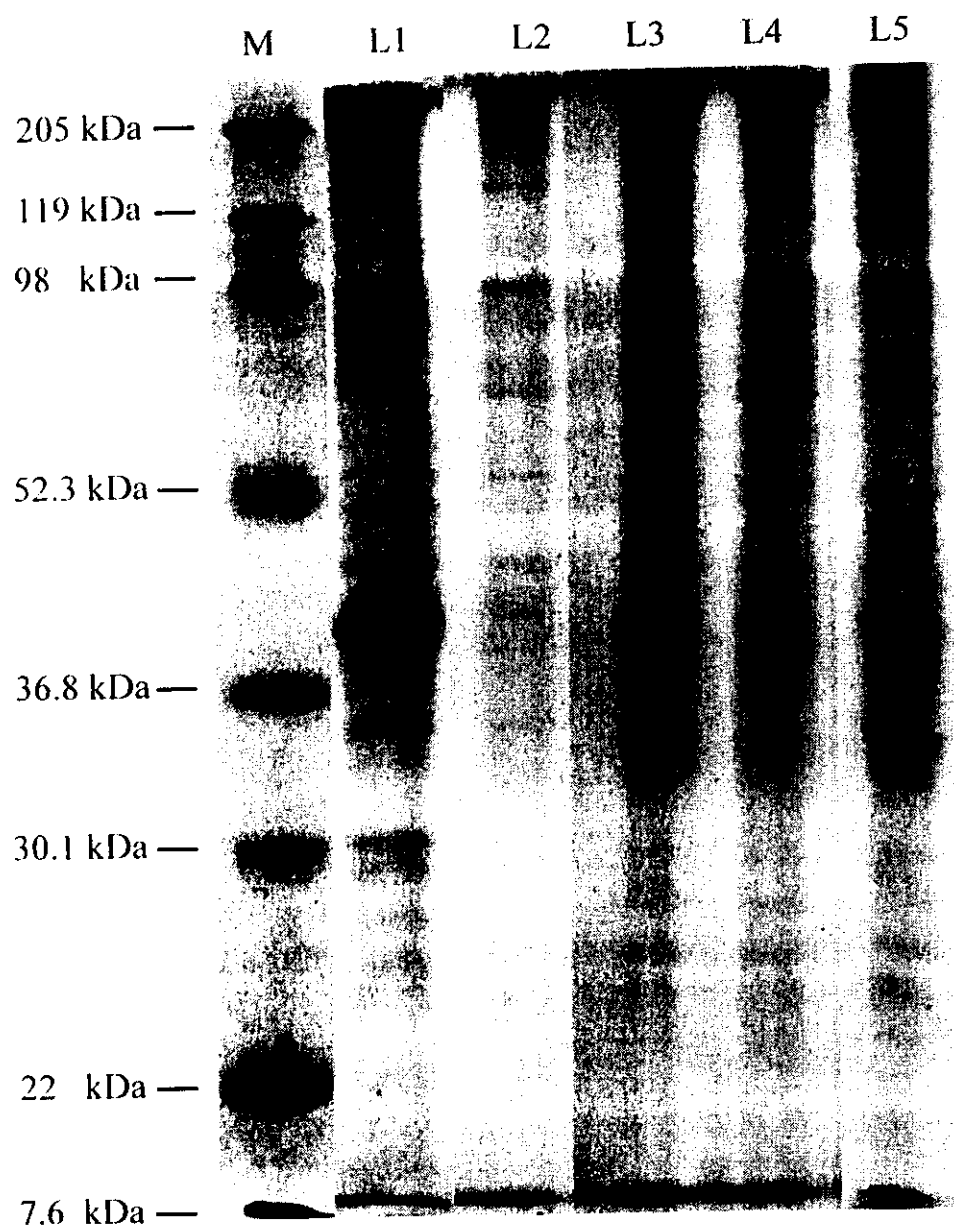
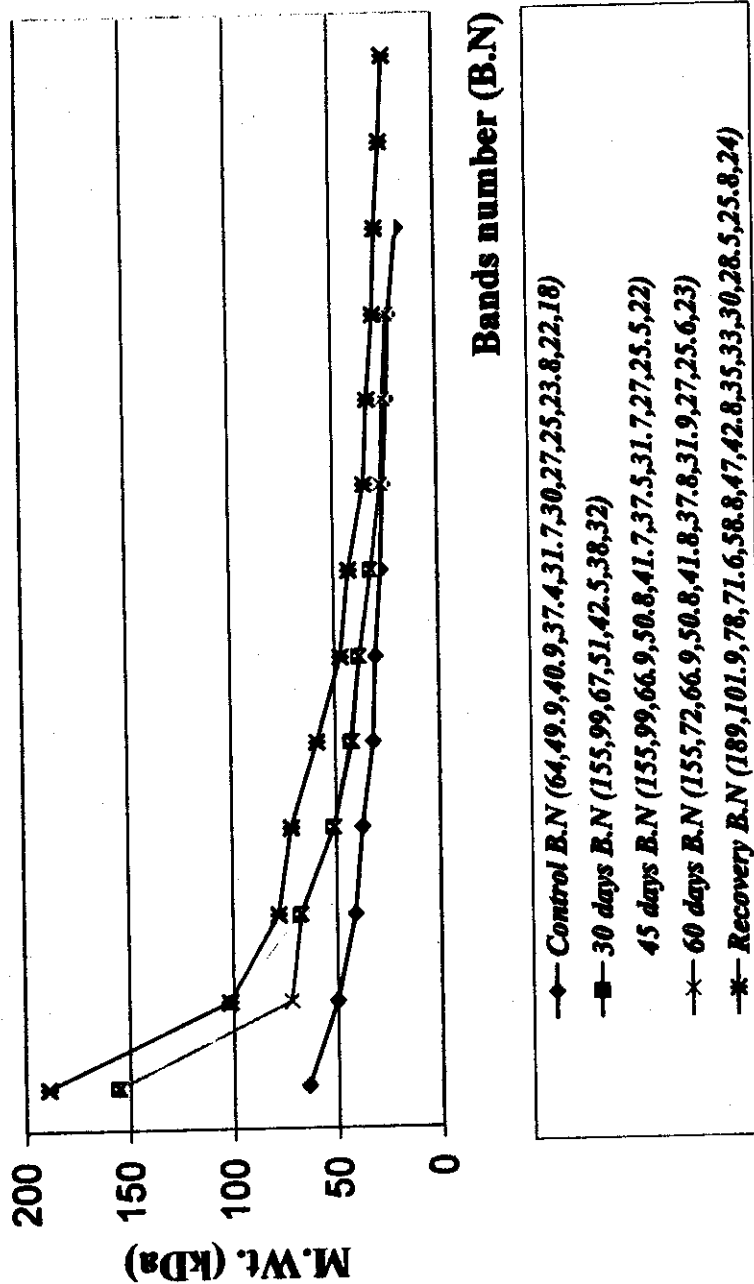


Fig (33): SDS-15% polyacrylamide gel electrophoresis of brain proteins extracted from rats exposed to microwave radiation and were given 0.1 ml Tomex. L: Lane, M: Protein molecular weight marker, L1: Control, L2: 30 days, L3: 45 days, L4: 60 days, L5: Recovery

Fig.(34): Banding pattern of proteins measured in brain of rats exposed to microwave & Tomex



increasing the time of exposure to 45 days, the number of bands increased revealing new protein fractions of molecular weight 41.7, 37.5, 31.7, 27, 25.5, 23 and 22 kDa. After 60 days of exposure some bands disappeared with molecular weight 99 and 22 KDa, while a new band appeared (M.W 72 kDa). New protein fractions appeared with molecular weight 189, 101.9, 78, 71.6, 58.8, 47, 42.8, 35, 33, 30, 28.5 and 24 kDa after removing the irradiation source for 30 days.

The analysis of proteins in Table (20), Fig. (35, 36), shows the banding pattern of proteins extracted from brain of rats exposed to mobile phone radiation with 900 MHz for 14, 30, and 45 days. The total number of bands in the exposed groups was 10, 15, and 15 bands respectively, while it recorded 11 bands in control group. Brain of recovery rats had 11 bands in SDS-PAGE. Exposure of rats to 900 MHz for 14 days revealed new synthesized polypeptides with molecular weight of 205, 114, 106.6, 96.8, 78, 62.5, 58.8, 47, 42.5 and 34.9 kDa comparing to the control. By increasing the time of exposure to 30 days, the number of bands increased and new polypeptides with molecular weight 191.3, 111.7, 85, 77, 61, 57, 46, 40, 29, 27.6, 24.9, 23 and 22 kDa appeared, while other polypeptides bands with molecular weight 114, 106.6, and 96.8 kDa were down regulated. After 45 days of exposure the results were nearly the same as at 30 days with the exception of the appearance of some fractions with molecular weight 198, 105.5 and 20.9 kDa. In the recovery group (30 days after the exposure) the number of bands in the brain decreased and some fractions with molecular weight 198, 112, 105.5, 85, 77.6, 23.5 and 20.9 kDa disappeared, while a new polypeptide band with M.W 37 kDa appeared clearly (Table 20) (Fig. 35, 36).

Table (21), Fig. (37, 38) compares the protein banding pattern of rats brain exposed to mobile phone radiation with 900 MHz together with the daily administration of Tomex during 14, 30 and 45 days. It showed a

variety of the total number of bands to 16, 18 and 17 respectively, comparing to the control (Table 21). After 14 days of exposure many new types of synthesized proteins with molecular weight 200, 112, 82.5, 76.6, 71, 62.9, 57, 46, 41.9, 36.3, 34, 32.7, 29.6 and 24 kDa were observed. Bands with molecular weight 189, 119, 77, 58, 54.9, 51.9, 50.7 and 23.9 kDa appeared as new fractions after 30 days of the chronic exposure (Table 21). By increasing the time of exposure to 45 days some polypeptide bands remained constant and others with molecular weight 195.7 and 84.5 kDa appeared. By leaving the animals 30 days after exposure as a recovery group, the number of protein bands in the brain decreased to 14 bands and some bands with molecular weight 195.7, 111.7, 55, 51.9, and 50 kDa were vanished and other bands with molecular weight 191, and 108.8 kDa were appeared (Table 21).

Table (20): SDS-PAGE banding pattern of proteins measured in brain cells of rats exposed to mobile phone radiation.

M.Wt (KDa)	Protein	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5
Band No.	Marker	(Control)	(14 days)	(30 days)	(45 days)	(Recovery)
1	205		205			
2					198	
3				191		
4	119					
5			114			
6					112	
7				111.7		111
8			106.6			
9					105.5	
10	98					
11			96.8			
12				85	85	
13			78			
14				77	77.6	
15		64				
16			62.5			
17				61.4		
18			58.8			
19				57.7	57.7	57.4
20	52.3					
21		49.9				
22			47			
23				46	46	
24						45.9
25			42.5		42	42
26				41.8		
27		40.9		40.3	40	40
28		37.4				37
29	36.8					
30			34.9	34.4	34	34.5
31		31.7				
32	30.1	30				
33				29	29	29.2
34		27.4		27.6	27.4	27.6
35		25.7				25.2
36				24.9	24.8	
37		23.8		23.4	23.5	
38	22	22		22		
39					20.9	
40		18				
No. of Fractions	7	11	10	15	15	10

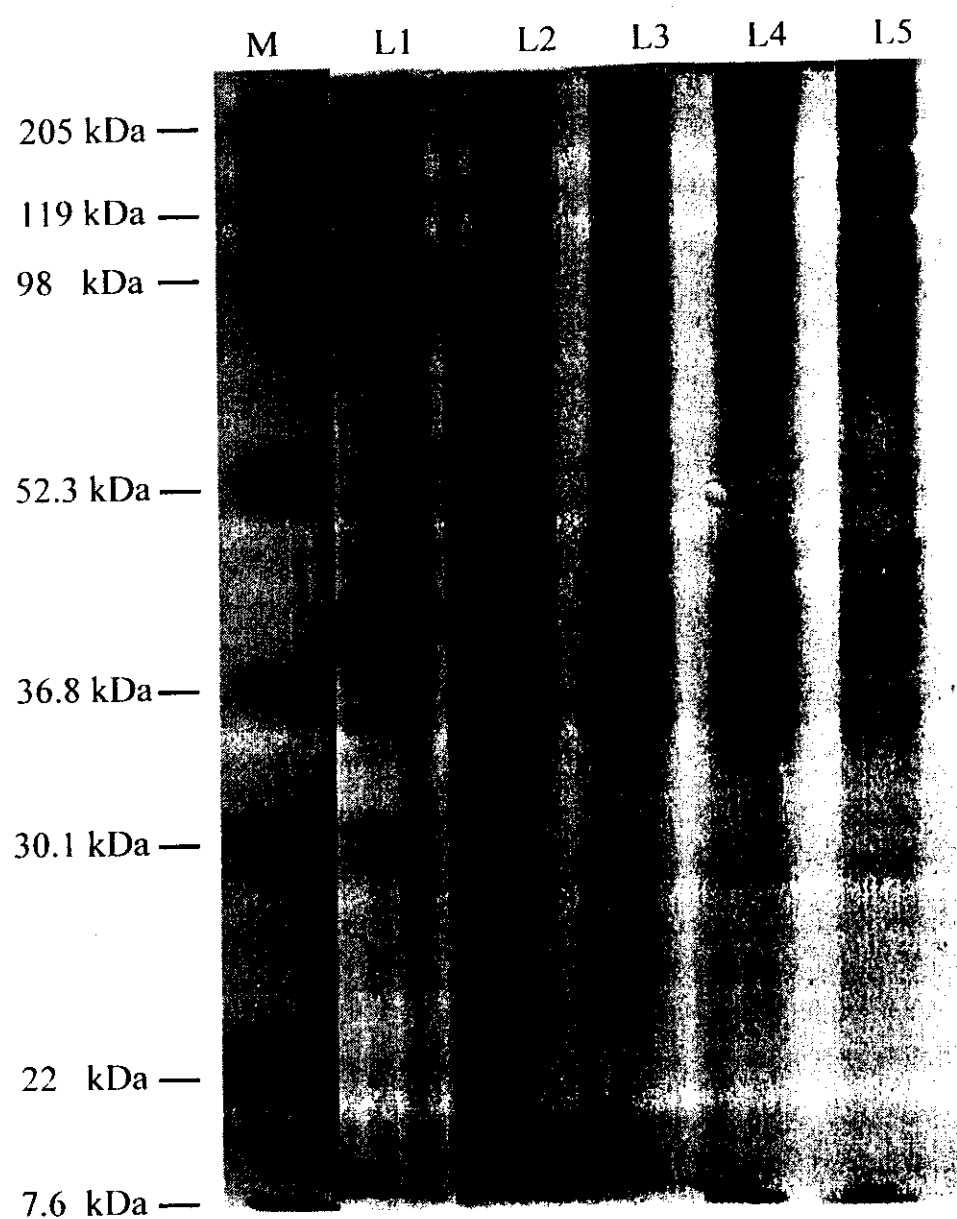
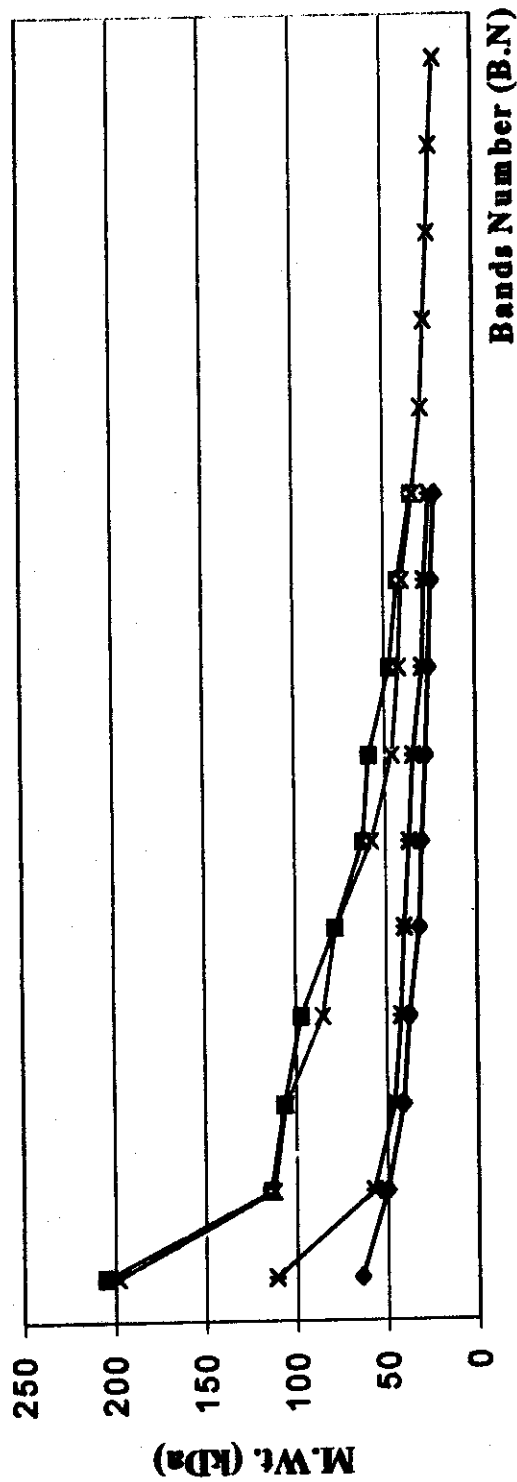


Fig (35): SDS-15% polyacrylamide gel electrophoresis of brain proteins extracted from rats exposed to mobile phone radiation. L: Lane, M: Protein molecular weight marker, L1: Control, L2: 14 days, L3: 30 days, L4: 45 days, L5: Recovery

Fig. (36): Banding pattern of protein measured in brain of rats exposed to mobile phone radiation



- ◆— Control B.N (64,49,9,40,9,37,4,31,7,30,27,4,25,7,23,8,22)
- 14 days B.N (205,114,106,5,96,8,78,62,5,58,8,47,42,5,34,9)
- ×— 30 days B.N (191,111,7,85,77,61,4,57,7,46,41,8,40,3,34,4,29,27,6,24,9,23,22)
- *— 45 days B.N (198,112,105,5,85,77,5,57,7,46,42,1,40,34,29,27,24,8,23,5,20,9)
- *— Recovery B.N (111,57,4,45,9,42,40,37,34,5,29,27,6,25)

Table (21): SDS-PAGE banding pattern of proteins measured in the brain cells of rats exposed to mobile phone & Tomex.

M.Wt (KDa)	Protein	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5
Band No.	Marker	(Control)	(14 days)	(30 days)	(45 days)	(Recovery)
1	205					
2			200			
3					195.7	
4						191
5				189		
6	119			119		
7			112	111.7	111.7	
8						108.8
9	98					
10					84.5	84.5
11			82.5	82.9		
12					78.5	78.5
13				77		
14			76.6			
15						72
16			71		71.6	
17				70.7		
18		64				
19			62.9			
20				58	58.8	58.8
21			57			
22				54.9	55	
23	52.3			51.9	51.9	
24				50.7	50	
25		49.9				
26			46	46.7	46.7	46.8
27				42	42.6	42.9
28			41.9			
29		40.9				
30		37.4				
31	36.8		36.3			
32			34	34.4	34.5	34.6
33					33	33
34			32.7	32.9		
35		31.7				
36	30.1	30				30
37			29.6	29.8	29.8	
38					28.4	28.7
39		27.4	27.9	27.9		
40						26
41		25.7	25.6	25.6	25.9	
42			24		24	24
43		23.8		23.9		
44	22	22				
45		18				
No. of Fractions	7	11	16	18	17	12

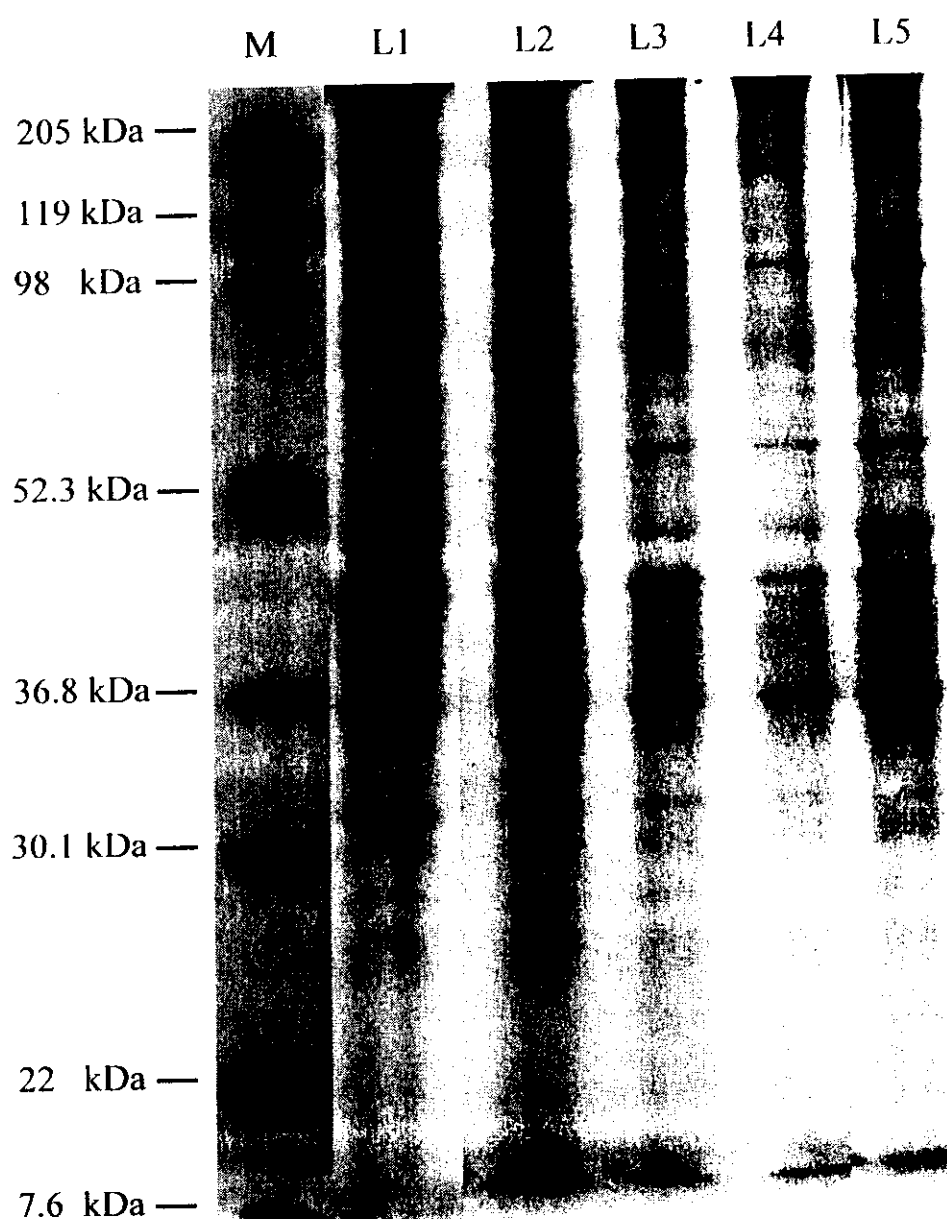


Fig (38): SDS-15% polyacrylamide gel electrophoresis of brain proteins extracted from rats exposed to mobile phone radiation and were given 0.1 ml Tomex. L: Lane, M: Protein molecular weight marker, L1: Control, L2: 14 days, L3: 30 days, L4: 45 days, L5: Recovery

Fig.(38): Banding pattern of proteins measured in the brain of rats exposed to mobile phone & Tomex

