

## CHAPTER 4

### RESULTS AND DISCUSSION

#### 4.1 Method Optimization

##### 4.1.1 Deposition Time and Potential

There are three most important conditions in stripping techniques namely, deposition time, deposition potential, and sample volume. Figure 3 shows the change in current signal for the same concentration of analyte at different deposition times. The signal tends to level off at 180 s and actually decreased at 240 s.

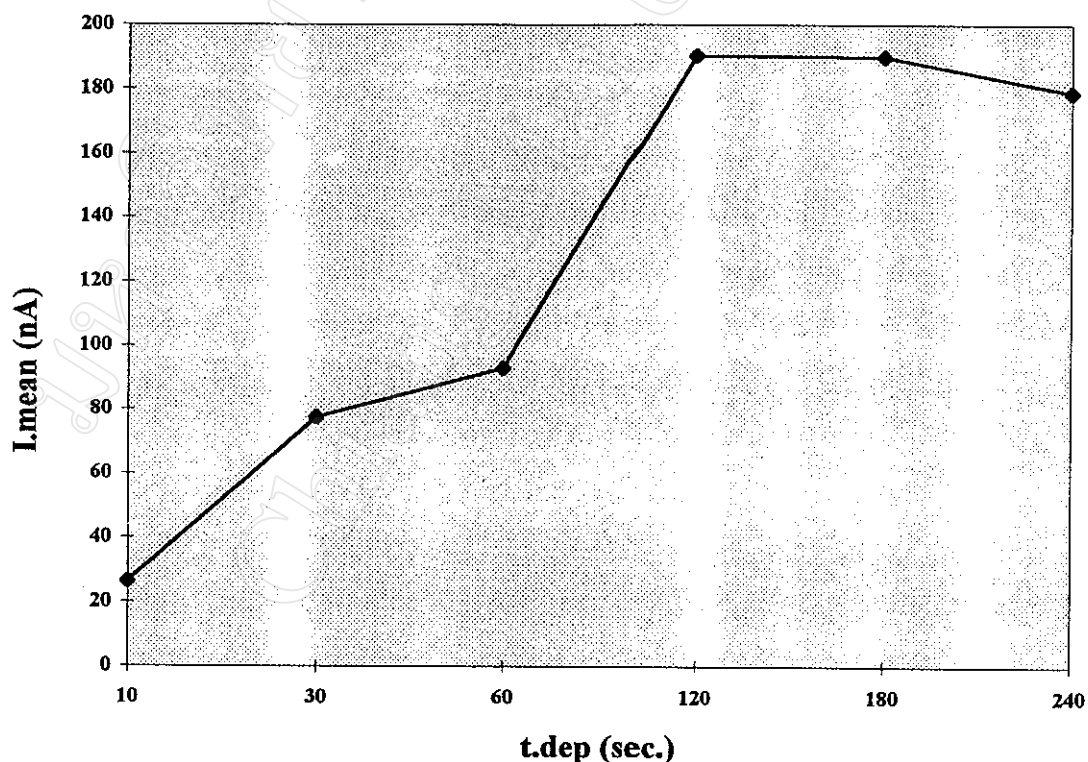


Figure 3 Change in Mean Current ( $I_{\text{mean}}$ , nA) against Deposition Time ( $t_{\text{dep}}$ , sec.)

Usually, the longer the deposition step the larger the amount of analyte available at the electrode during the stripping (measurement) step. However, in many cases, long periods may result in interferences because of the formation of intermetallic compounds or saturation of the mercury (Hg) which may affect the analysis. In this work, 120 s was found to be the optimum deposition time sufficient to deposit the analyte from the solution onto the electrode and obtain well-defined stripping peaks without the need for lengthy analysis time.

As regards the deposition potential, it is applied to the working electrode to cause the metal of interest to deposit onto its surface. A deposition potential of  $-1.1$  V (versus Ag-AgCl electrode) was employed for the deposition of Pb in this work based on an earlier work of Wojciechowski and Balcerzak (1990). They have demonstrated the effect of the deposition potential on the square-wave stripping peak current of Pb in the presence of dissolved oxygen. That is, square-wave anodic stripping voltammetric measurements in the presence of oxygen showed a significant increase in slope when the deposition potential was changed from  $-0.9$  to  $-1.0$  V and that the slope increased slightly when the deposition potential was changed from  $-1.0$  to  $-1.1$  V. Moreover, a lower slope for the curve of a nondeaerated solution at  $-0.9$  V deposition potential was observed which is due to chemical stripping of the deposited Pb by hydrogen peroxide that is formed when oxygen is reduced at potentials more positive than  $-1.0$  V (Wojciechowski and Balcerzak, 1990).

In addition, since acidic medium was used, a deposition potential more negative than  $-1.2$  V cannot be applied. This is to avoid a loss in sensitivity toward the metal ion of interest due to  $H_2$  evolution background reaction which occurs at negative potentials (Wang, 1985). That is, for very high  $H^+$  concentrations or at more negative potentials, the evolution of hydrogen gas on the electrode surface (large  $H_2$  bubbles) decreases the electrode surface, so current signals may also decrease (Ostapczuk, 1992).

#### 4.1.2 Supporting Electrolyte Modification

Table 1 lists the components of the matrix modifier suggested by Jagner and co-workers (1994) for the determination of Pb in whole blood as well as the changes adopted in this study.

Table 1 Matrix Modifier Components

Matrix Modifier (Jagner <i>et al.</i> , 1994)	Matrix Modifier (the present work)
1 M HCl containing :	1 M HCl containing :
500 mg/l Hg (II)	-
200 mg/l each of Al(III) and Mn(II)	200 mg/l each of Al(III) and Mn(II)
4 mg/l Bi(III)	-
0.06 M EDTA	0.001 M EDTA
0.05 M CaCl <sub>2</sub>	0.05 M CaCl <sub>2</sub>
10% v/v Triton X-100	0.01% v/v Triton X-100

Generally, the supporting electrolyte to be used for analysis must allow signal enhancement of the required metal species to be determined, enable the use of one or more complexing agents to increase selectivity, and allows the masking of higher concentration elements. In particular, the purpose of the matrix-modifying solution in this study is to transfer the whole blood Pb into chemically well-defined and electroactive forms and, at the same time, make sample-to-sample variations with respect to ionic composition, viscosity, and surface activity negligible (Jagner *et al.*, 1994).

Octapczuk (1992) has previously demonstrated that 0.5 M hydrochloric acid is sufficient to mobilize whole blood Pb into Pb(II) chlorocomplexes. However, it is possible that a small fraction of the whole blood Pb could be strongly bound to blood components such as those containing oxygen and/or nitrogen ligand atoms. The

presence of aluminum(III) and manganese(II) in the matrix-modifying solution will help displace the Pb bound to such components. They shift the equilibrium in favor of aluminum(III) and manganese(II) oxygen and/or nitrogen compounds (Jagner *et al.*, 1994).

With regard to the composition of the matrix-modifier in this study, four major modifications were made. First, TMF electrodes were used rather than having the mercury film plated *in situ*. As demonstrated in other investigations (Almestrand *et al.*, 1987; Jagner *et al.*, 1981; Ostapczuk, 1992) preplated Hg films work well in Pb analysis in blood matrix. Additionally, it has been shown previously that preplated TMF electrodes perform well even in non-deaerated solutions containing Pb using the square-wave mode (SQWMODE) in anodic stripping voltammetry (Wojciechowski and Balcerzak, 1990). This is because the fast-scanning ability of square-wave voltammetry allows for the completion of the stripping step before any significant oxidation of the amalgam by diffusing oxygen can occur. Moreover, initial trials done for this work with sample solutions containing blood matrix indicated that *in situ* plating of Hg film did not give well-defined Pb stripping peaks.

Second, the EDTA concentration was reduced mainly because the original concentration gave a cloudy solution and possible effects of this on the efficiency of the electrodes was considered. Therefore, the concentration of EDTA in the matrix modifier used is at a level at which no suspension of solids was observed.

Third, Bi(III) was excluded in the matrix modifier because quantitation of the analyte (Pb) was done using the simple calibration curve technique. Thus, no internal standard was needed, which was the main purpose of Bi(III) in the previous work. Furthermore, when the internal standard method for quantitative analysis was tried, the obtained calibration curves did not give accurate results for the BLLRS standards analysed.

Lastly, the concentration of Triton X-100 in the previous work was reduced a thousand-fold. It was noted that when the original concentration was used, it gave a very viscous solution. Since the effect of this surface active agent is to suppress the sudden surge of current signal at the beginning of the oxidation of the metal species, a very high concentration of Triton X-100 might totally mask the signal. This may occur mainly due to the tendency of surface-active substances to adsorb on the mercury electrode, thus inhibiting the metal deposition and/or stripping processes. Therefore, the original concentration of 10% was initially reduced to 0.02% then 0.015%, and finally to 0.01%. Contrary to what is expected however, it was observed that among the three concentrations mentioned, the higher levels of Triton X-100 produced an increase in the peak current of Pb in the sample matrix. This resulted to a subsequent rise in the Pb concentration obtained for BLLRS 896. This effect is shown in Table 2.

Table 2 Effect of Different Levels of Triton X-100 on Pb Concentration

Triton X-100 (%)	Observed Conc. of BLLRS 896 (Expected Value, $\mu\text{g}/\text{dl}$ )	Difference, $\mu\text{g}/\text{dl}$ (% increase)
0.02	134.7 (34.3)	100.4 (29)
0.015	87.5 (34.3)	53.2 (16)
0.01	37.1 (34.3)	2.8 (8)

This trend is similar to a reversal of the depression effect which has been observed in some cases of high concentration of surface-active substances. Comprehensive studies of the possible effects of surface-active substances on the response of anodic stripping voltammetric analysis have been carried out in the past such as the works of Brezonik *et al.* (1976) and Sagberg and Lund (1982) as cited by Wang (1985). In both studies, certain surface-active substances including alginic acid, Triton X-100, and alkaline phosphatase gave a 65-90% decrease in the stripping peak current. These studies demonstrated that not all surface-active substances exhibited a

depression effect, and that no general trend vis-à-vis their effect on stripping peak current could be established. Therefore, it is likely that the effects produced by surface-active compounds depend on different factors including their chemical structure, their concentration, their environment, the metal determined, the deposition potential, and the type of electrode used (Wang, 1985).

For the present work, 0.01% level of Triton X-100 was considered sufficient to suppress any surge in stripping peak current and, at the same time, make variations in sample viscosity and surface activity negligible.

#### 4.1.3 Detection Limit of Method

During the process of Pb analyses, some 42 calibration curves were used for reference blood materials (BLLRS and QC materials) and samples. These curves were later used in calculating the method detection limit. The range, mean and SD of correlation coefficients ( $r$ ) from the different calibration curves are shown in the following table.

Table 3 Mean, SD and Range of Correlation Coefficient ( $r$ ) for Calibration Curves

No. of Calibration curves	Range of $r$	Mean $\pm$ SD
42	0.9971 - 0.9999	0.9995 $\pm$ 0.0006

The method detection limit was calculated according to the formula given by Miller and Miller (1993) and based on the calibration curves set up for the Pb analyses. The mean  $\pm$  SD detection limit was about 0.08  $\pm$  0.06  $\mu\text{g/dl}$ . A sample calculation is given in Appendix II.

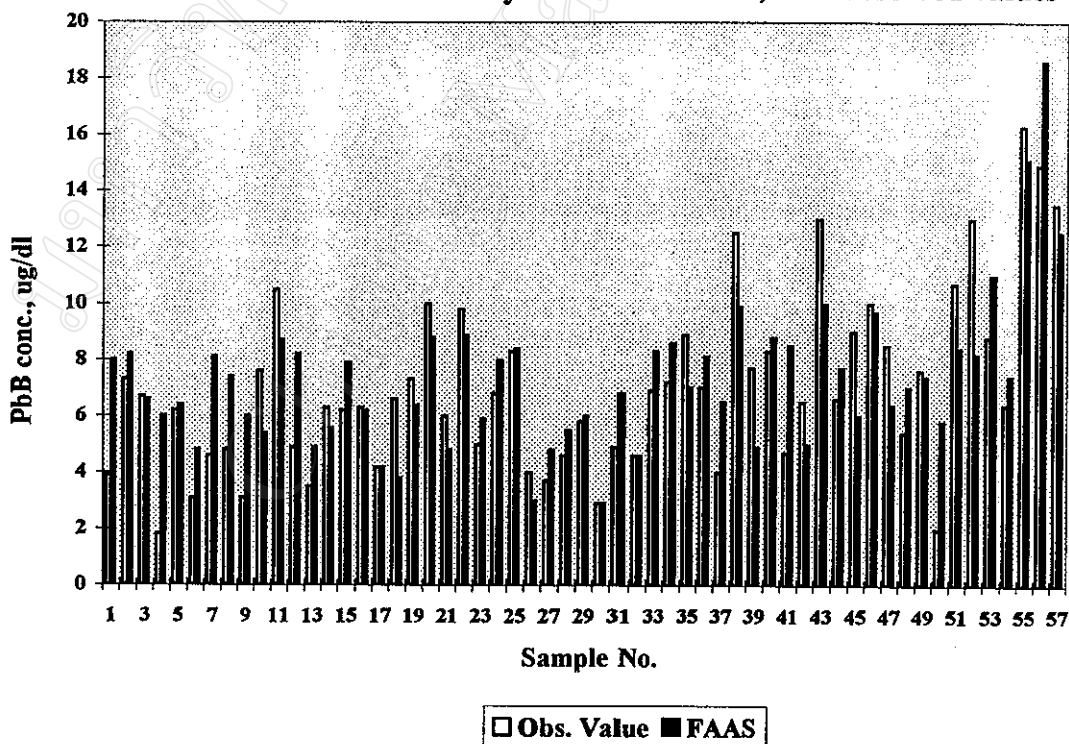
#### 4.1.4 Analysis of Stored Blood Samples with Different Anticoagulants

Stored whole blood samples with sodium heparin (n=38) and K<sub>2</sub>-EDTA (n=57) as anticoagulants were analyzed and the results were compared to the concentrations previously obtained using the AAS method. In both sets of samples, the observed concentrations exhibited fluctuations from the AAS results. Correlation coefficients of observed values for the samples in K<sub>2</sub>-EDTA and sodium heparin versus the AAS results were 0.75 and 0.57, respectively. Figures 4 and 5 show the results of Pb determinations of stored samples with K<sub>2</sub>-EDTA and sodium heparin, respectively as compared with the initial results obtained using flame AAS (FAAS). Although the association is not remarkably linear, K<sub>2</sub>-EDTA as anticoagulant seems to affect the Pb concentration of stored blood to a lesser extent than sodium heparin does when the method in this study is used.

$$r = 0.7531;$$

$$\text{regression line equation : } y = 0.6183(x) + 3.031$$

where : y ⇒ FAAS results; x ⇒ observed values

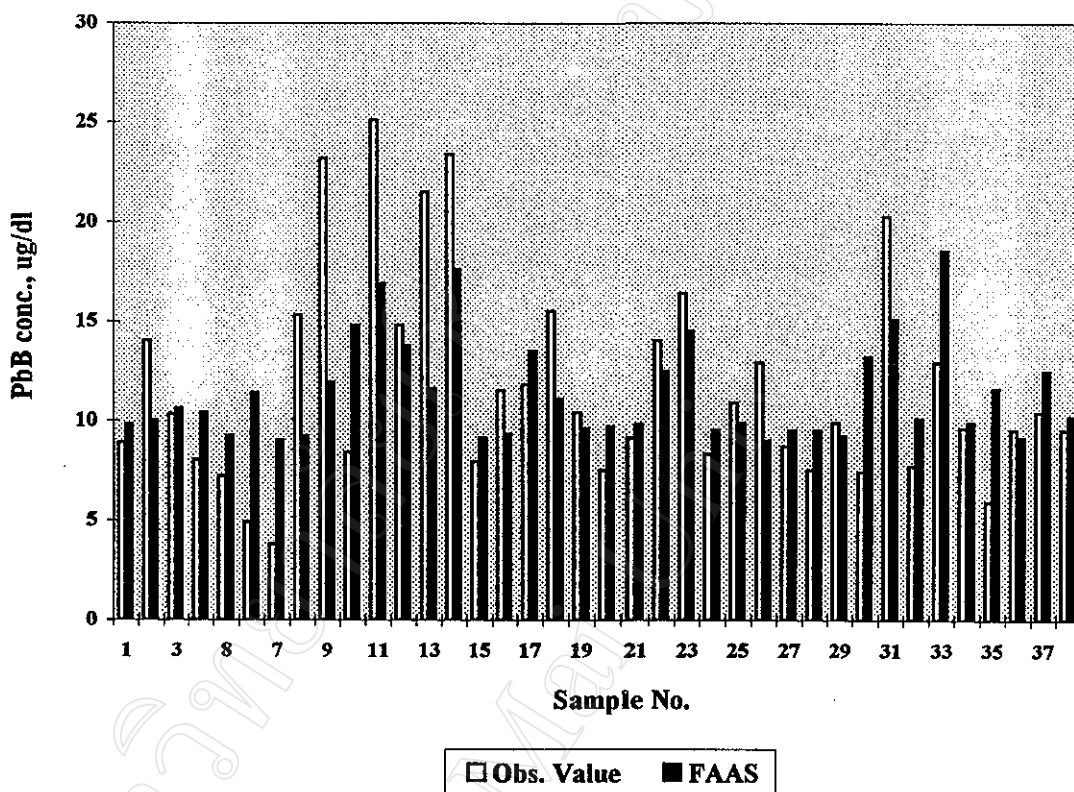


**Figure 4 Comparison of Observed Values for Blood Samples (stored with K<sub>2</sub>-EDTA anticoagulant) with Results from Initial FAAS Analysis**

$r = 0.5682$ ;

regression line equation :  $y = 0.2789(x) + 8.113$

where :  $y \Rightarrow$  FAAS results;  $x \Rightarrow$  observed values



**Figure 5 Comparison of Observed Values for Blood samples (stored with sodium heparin anticoagulant) with Results from Initial FAAS Analysis**

#### 4.1.5 Accuracy

In order to validate the ASV in square-wave mode (SQWASV) technique used in this work, thirty quality control (QC) materials in the concentration range of 4.97 - 89.30  $\mu\text{g Pb/dl}$  were analyzed. The results obtained by several techniques at a large number of laboratories and those obtained in this study gave a correlation coefficient,  $r$  equal to 0.9792. Figure 6 shows how the results from this study varied with those obtained previously. The results from this work tend to be higher than the expected values. Therefore, it must be noted that the results reported for Pb in the blood samples analyzed in this study have not been corrected. As a whole, the results using



SQWASV method agree satisfactorily with the results obtained by other analytical methods.

$r = 0.9792;$

regression line equation :  $y = 0.8766(x) + 0.1852$

where :  $y \Rightarrow$  mean expected value;  $x \Rightarrow$  mean observed value

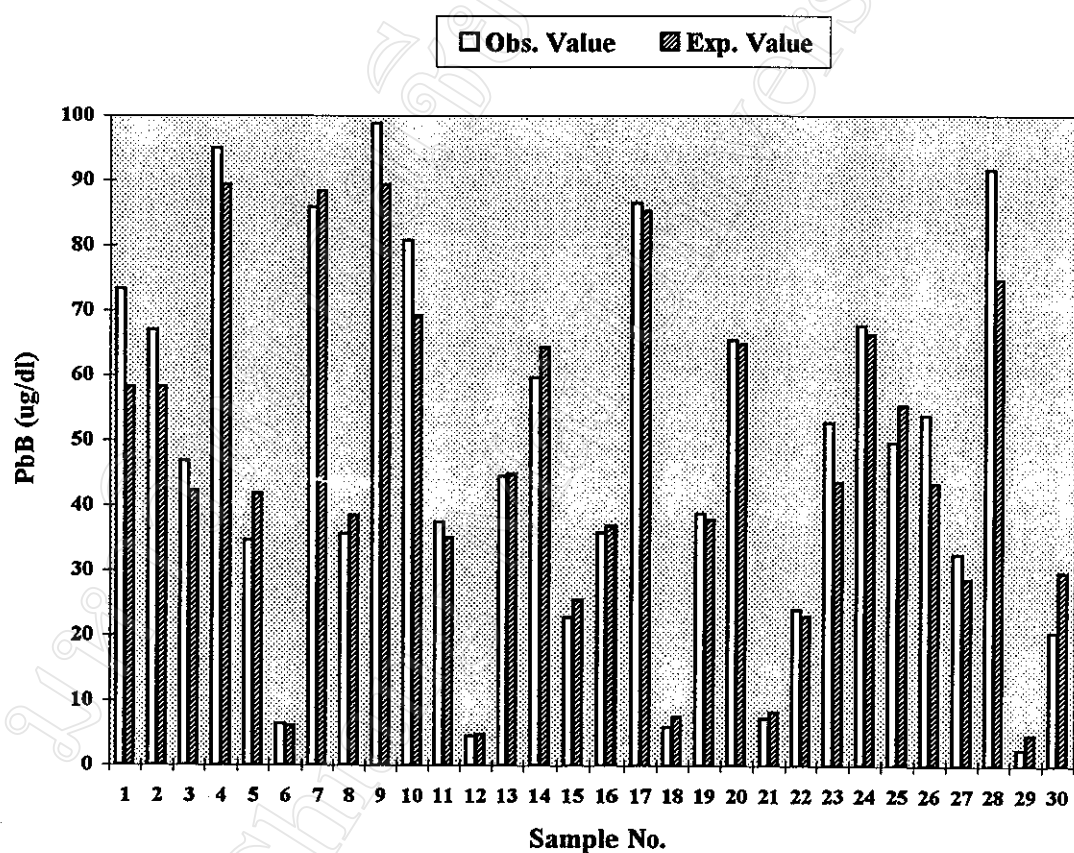


Figure 6 Variation of Mean Observed Values with Mean Expected Values for QC Materials

#### 4.1.6 Precision

The precision of the test method was tested by analyzing three BLLRS standards. The results obtained were compared to target values based on ICP-IDMS determination for each standard. Although only five repetitive analyses were made, it can be stated that the precision expressed in terms of % CV was better than 10% as indicated in Table 4. The % CV was calculated as:  $(SD/Mean)*100$ .

Table 4 Analysis of Three BLLRS Standards for Test of Precision

Sample	Target Value, $\mu\text{g}/\text{dl}$ (ICP-IDMS method)	Observed Value	
		Mean $\pm$ SD ( $\mu\text{g}/\text{dl}$ )	% CV
BLLRS 196	10.3	10.2 $\pm$ 0.3 (n=5)	2.9
BLLRS 896	34.3	33.2 $\pm$ 1.3 (n=5)	3.9
BLLRS 996	15.2	16.3 $\pm$ 1.2 (n=5)	7.6

#### 4.1.6 Recovery

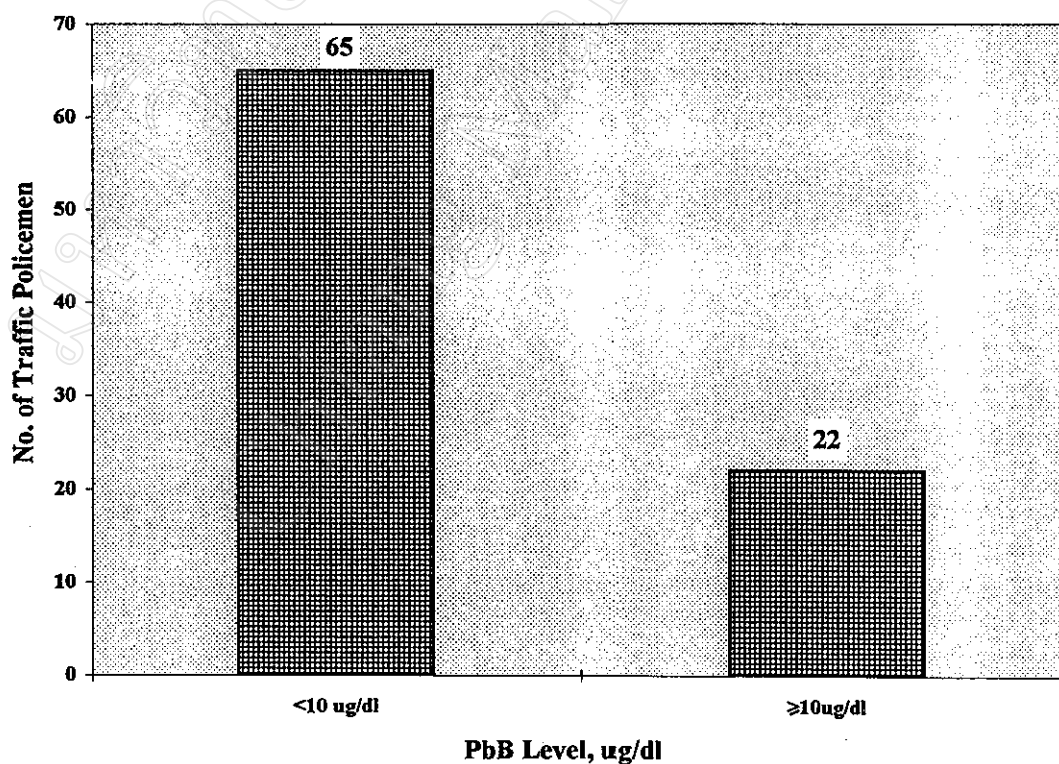
The mean % recovery of the test method was 101%. This was based on the analysis of the BLLRS standards listed in Table 5.

Table 5 % Recovery

Sample	Target Value, $\mu\text{g}/\text{dl}$ (ICP-IDMS method)	Observed Value	
		Mean $\pm$ SD ( $\mu\text{g}/\text{dl}$ )	% Recovery
BLLRS 196	10.3	10.2 $\pm$ 0.3 (n=5)	99
BLLRS 896	34.3	33.2 $\pm$ 1.3 (n=5)	97
BLLRS 996	15.2	16.3 $\pm$ 1.2 (n=5)	107

## 4.2 Pb Analysis in Blood Samples

A total of 87 blood samples were collected and analyzed for their Pb concentrations. The study population had a mean age  $\pm$  SD of  $35 \pm 5.7$  years and the mean years spent working as a traffic policeman was  $8.4 \pm 6.3$ . The crude overall PbB mean was  $8.1 \mu\text{g}/\text{dl}$  with values ranging from  $1.1 - 21.9 \mu\text{g}/\text{dl}$ . There were more traffic policemen with a PbB level  $<10 \mu\text{g}/\text{dl}$  than those with  $\geq 10 \mu\text{g}/\text{dl}$  as shown in Figure 7. Table 6 describes the PbB distribution observed in terms of arithmetic mean ( $\mu\text{g}/\text{dl}$ ), SD, range and frequency in different age groups.



**Figure 7 Number of Traffic Policemen with PbB <10ug/dl and ≥10 ug/dl (1996)**

**Table 6 Frequency, Range, Mean PbB and SD According to Age Groups**

Age	N	Mean $\pm$ SD ( $\mu\text{g}/\text{dl}$ )	Min - Max ( $\mu\text{g}/\text{dl}$ )
24 - 30	23	8.5 $\pm$ 5.0	1.7 - 21.9
31 - 38	49	8.4 $\pm$ 4.8	1.1 - 21.0
39 - 55	15	6.4 $\pm$ 2.7	2.2 - 11.1
<b>Total</b>	<b>87</b>	<b>8.1 <math>\pm</math> 4.6</b>	<b>1.1 - 21.9</b>

There is no significant difference in mean PbB among the age groups described. Moreover, Pearson's correlation coefficient obtained for the linear association of blood lead with age was -0.0059. This reveals that age is not correlated with PbB in this study. Use of the log-transformed PbB variable in the correlation analysis did not improve the strength or significance of the association.

PbB levels according to smoking habits and alcohol consumption are presented in Table 7.

**Table 7 Mean PbB for Smokers, Non-Smokers, Drinkers and Non-Drinkers of Alcohol**

Variable	Category	N	Mean $\pm$ SD ( $\mu\text{g}/\text{dl}$ )	Min - Max ( $\mu\text{g}/\text{dl}$ )	P-value
Smoking	1 = No	56	7.7 $\pm$ 4.1	1.1 - 17.8	0.2994
	2 = Yes	31	8.8 $\pm$ 5.4	2.0 - 21.9	
Alcohol consumption	1 = No	9	7.6 $\pm$ 3.8	1.1 - 21.9	0.7570
	2 = Yes	78	8.1 $\pm$ 4.6	3.0 - 14.1	

The PbB levels for smokers were higher compared to nonsmokers; similarly, the mean PbB concentration for alcohol-drinkers in comparison with non-drinkers of alcohol is higher. However, differences are not very remarkable and not statistically significant. Moreover, about 90% of the traffic policemen are alcohol drinkers therefore it is presumptuous to assume that higher PbB levels for this group is caused by alcohol consumption alone. It is likely that alcohol is only a confounding factor to their total exposure and a single factor acting in isolation is difficult to determine.

In order to see whether the combined habits of smoking *and* alcohol consumption will show more significant association with PbB levels, subjects were grouped according to three categories as in Table 8. Although the mean PbB level for those who consume *both* cigarettes and alcohol is higher than the other groups, the difference is again not statistically significant which may be explained by the rather small sample size. Moreover, any possible linear association of PbB with these potential determinants cannot be stated for the reason that exact data with regard to the number of cigarettes and/or amount of alcohol consumed per day were not considered in the questionnaire.

Table 8 Mean PbB for Neither Smokers nor Alcohol-drinkers<sup>1</sup>, Either Smokers or Alcohol-drinkers<sup>2</sup>, Smokers and Alcohol-drinkers<sup>3</sup>

Group	N	Mean $\pm$ SD ( $\mu\text{g}/\text{dl}$ )	Min - Max ( $\mu\text{g}/\text{dl}$ )
1	7	7.0 $\pm$ 3.2	3.0 - 11.9
2	51	8.0 $\pm$ 4.2	1.1 - 17.8
3	29	8.6 $\pm$ 5.5	2.0 - 21.9

The above results indicate that non-occupational determinants like age, smoking and alcohol consumption do not appear as correlates of PbB levels in this study. Notwithstanding the non-significance in differences of mean PbB levels for nonconsumers and consumers of cigarettes and alcohol, slight increases were noted for

the latter. Such a trend is consistent with other investigations (Hense *et al.*, 1992; Wietlisbach *et al.*, 1995) wherein lifestyle variables like alcohol consumption (particularly of wine) and cigarette smoking are strong determinants of PbB levels. Wietlisbach and co-workers (1995) cited the estimates of the Pb content of a cigarette -- from 0.5 to 2 µg, with about 6% passing into mainstream smoke -- according to Chiba and Masironi (1992). Thus, the association of cigarette smoking to increased PbB levels might, to some extent, be traced to this fact. Smoking may also enhance the Pb intake by more frequent hand-mouth contacts (Berode *et al.*, 1991) or through transportation of airborne Pb into the lungs by smoke particles (Clench-Aas *et al.*, 1990) as cited by Wietlisbach *et al.* (1995).

Higher mean PbB levels have also been found for wine drinkers in past studies (Hense *et al.*, 1992; Wietlisbach *et al.*, 1995). The cause for this association has been accounted for, at least partly, by the additional intake of Pb supplied by wine. Since wine is known to contain some level of Pb (Ewers and Schlipkötter, 1991), it is likely that a substantial part of the total Pb intake for regular drinkers may come from this source. As mentioned beforehand, estimates for the Pb intake arising from smoking and alcohol-drinking which can either substantiate this trend or not cannot be made in this study. As such, these are presented only as possible reasons for the observed higher mean PbB level observed for Group 3 in Table 8. In order to have a clearer and more definite picture of this trend however, testing a bigger sample size is probably necessary.

Tables 9 and 10 show the differences in mean PbB concentrations according to certain occupational factors such as the type of masks worn and the number of hours spent on the road each day.

**Table 9 Mean PbB Levels According to Type of Mask Used**

Type of mask used	N	Min - Max (µg/dl)	Mean ± SD (µg/dl)	P-value
1 = Filter mask	43	1.1 - 16.9	7.2 ± 3.9	0.0255
2 = Cloth mask	24	1.3 - 21.9	9.9 ± 5.6	

**Table 10 Mean PbB Levels According to No. of Hours Spent on the Road**

# Hours on road/day	N	Min - Max (µg/dl)	Mean ± SD (µg/dl)	P-value
0 = office work only	20	1.7 - 17.8	7.9 ± 4.1	0.0404
1 = 1-2 hours	12	3.5 - 16.9	10.9 ± 5.2	
2 = ≥ 3 hours	55	1.1 - 21.9	7.6 ± 4.5	

The preceding tables suggest that the PbB levels of traffic policemen are more influenced by work-related variables such as the kind of masks they use at work and the length of time they spend on the road. The data used to calculate the results in Table 9 excluded Pb levels of traffic policemen who are not directly involved with traffic work (# hours on road/day = 0 in Table 10) to see any association of the type of mask used with the PbB levels of those who work on the roads. The mean PbB level for traffic policemen who use cloth mask is significantly higher than those who use filter masks. This implies that filter masks are more effective protective gadgets for traffic policemen against Pb exposure. This corresponds to the results of a previous evaluation on the efficacy of masks used by Chiang Mai City traffic policemen against airborne Pb inhalation (Vongchak *et al.*, 1996). Based on the incidence of high PbB levels ( $\geq 10$  µg/dl), it was found that latex masks which consist of a toxic gas cartridge and a dust filter provide better protection against Pb exposure than cloth masks which are similar to those used by medical staff.

Additionally, traffic policemen who spend 1 - 2 hours on the road have significantly higher mean PbB level compared to those in the last category. Possible reasons may be given for this trend. First, traffic policemen who spend 1 - 2 hours on the road might do so during the heavy traffic period either in the morning or late afternoon, when the traffic volume is much higher than during the rest of the day. The higher density of traffic will contribute to a higher tendency of exposure. Second, it has been shown previously that air Pb levels in Chiang Mai City vary depending on the conditions prevailing at different roadsites such as high density of traffic and the presence of construction activities (Kang, 1996). Thus, it is assumed that the extent of Pb exposure of traffic policemen will likewise vary depending on the roadsites they work in. Moreover, the awareness factor among traffic policemen to protect themselves against possible Pb exposure must be taken into account. In relation to this, the type of masks they use and the regularity of usage of such must also be considered. It has been previously determined that a change of mask dust filters every 2 - 2.5 weeks during dry season and every 3 weeks during rainy season ensures better protection against Pb exposure (Vongchak *et al.*, 1996). Such factors therefore are likely to influence the total exposure of traffic policemen. For instance, the significantly lower mean PbB level for those who spend  $\geq 3$  hours on the road each day appears to be attributed to this awareness factor. That is, the longer time traffic policemen work on the road, the higher probability that they protect themselves regularly with their masks.

Mean PbB level for the first group in Table 10 does not vary significantly with that of the second group. Since rotation of tasks is carried out among traffic policemen, they can be assigned to work in the office after a certain period of traffic work. This is done to reduce excessive exposure and, at the same time, allow their Pb levels to lower. The length of time it takes for PbB to go down and level off at lower concentrations may vary among individuals depending on their body burden. As such, the mean PbB level for the first group may reflect the leveling off of Pb in individuals



who have recently been exposed and may require some time for their PbB levels to reach lower concentrations.

### 4.3 Risk Assessment of Pb Exposure

Even low levels of PbB are considered hazardous and are a public health concern. For instance, surveys of adult general population with mean PbB levels around 15.0 µg/dl observed positive associations between PbB and blood pressure or left ventricular hypertrophy over the entire range of PbB. Likewise, it is interesting to note that the possibility that health effects may even be restricted specifically to low levels of PbB and that they are likely to disappear at higher PbB concentrations exists (Goyer, 1993; Hense *et al.*, 1992). As such, an exact definition of a threshold value of PbB level below which untoward health impacts can be safely ruled out is difficult to state.

The range of PbB found in this study, except for two cases with PbB  $\geq 20$  µg/dl (maximum = 21.9 µg/dl), was relatively low with respect to the WHO limit value for Pb in blood (20 µg/dl) (WHO, 1987) set for general populations. Nevertheless, a PbB level  $\geq 10$  µg/dl which causes the most sensitive effect in adults was taken as the basis to assess the risk of possible excessive exposure among participants in this study. At a PbB level of 10 µg/dl, ALAD inhibition during heme synthesis is manifested. The prevalence of PbB  $\geq 10$  µg/dl would suggest the risk of exposure for vulnerable groups such as children and women of childbearing age for which measures of intervention and prevention should be taken.

Likewise, an attempt to see the effect, if any, of certain factors as regards their influence on the prevalence of PbB  $\geq 10$  µg/dl was made. The frequency of PbB  $\geq 10$  µg/dl corresponding to two potential risk factors were compared. That is, the odds of exposure among the "diseased" -- or in this case, among the subjects with PbB levels  $\geq 10$  µg/dl, a level which translates to potential health impacts -- is divided by the odds

of the exposure among the "non-diseased" (i.e., those with PbB < 10 µg/dl) to form the odds ratio. The odds ratio for different variables were calculated using the Epi Info 6.0 system and a sample calculation is shown in Appendix III. An odds ratio >1.0 represents an association between the potential risk factor and getting PbB ≥ 10 µg/dl. The following table lists specific variables and the corresponding prevalence odds ratio of having PbB levels ≥10 µg/dl among traffic policemen.

Table 11 Ratios of the Odds for PbB levels ≥10µg/dl Against Potential Risk Variables

Variable	OR*	95% Confidence Interval
≥ 1 hour on road	1.47	0.39 < OR < 6.02
Cloth Mask	1.68	0.50 < OR < 5.67
Smoking and Alcohol	2.14	0.23 < OR < 49.86

\*Odds Ratio

For policemen involved with traffic work, number of hour(s) ≥1 spent on the road was associated with prevalence odds for PbB ≥ 10 µg/dl approximately 1.5-fold higher in comparison with those who work in the office. Moreover, the risk of increased exposure for this group is enhanced depending on the availability and use of exposure preventive measures. Using cloth masks rather than filter masks, in particular, was found to increase by about 1.7 times the likelihood of having PbB ≥ 10 µg/dl. With regard to certain life style factors, smoking together with alcohol consumption was found to increase twice the odds of having PbB ≥10 µg/dl. Although all potential risk factors tested showed some degree of association for contributing to high Pb concentrations, the odds ratios were not statistically significant. This is possibly due to the rather small sample size of traffic policemen participating in the present study.

The implications for effective protection against over-exposure in terms of the availability of appropriate masks and the regularity of using such materials at work is

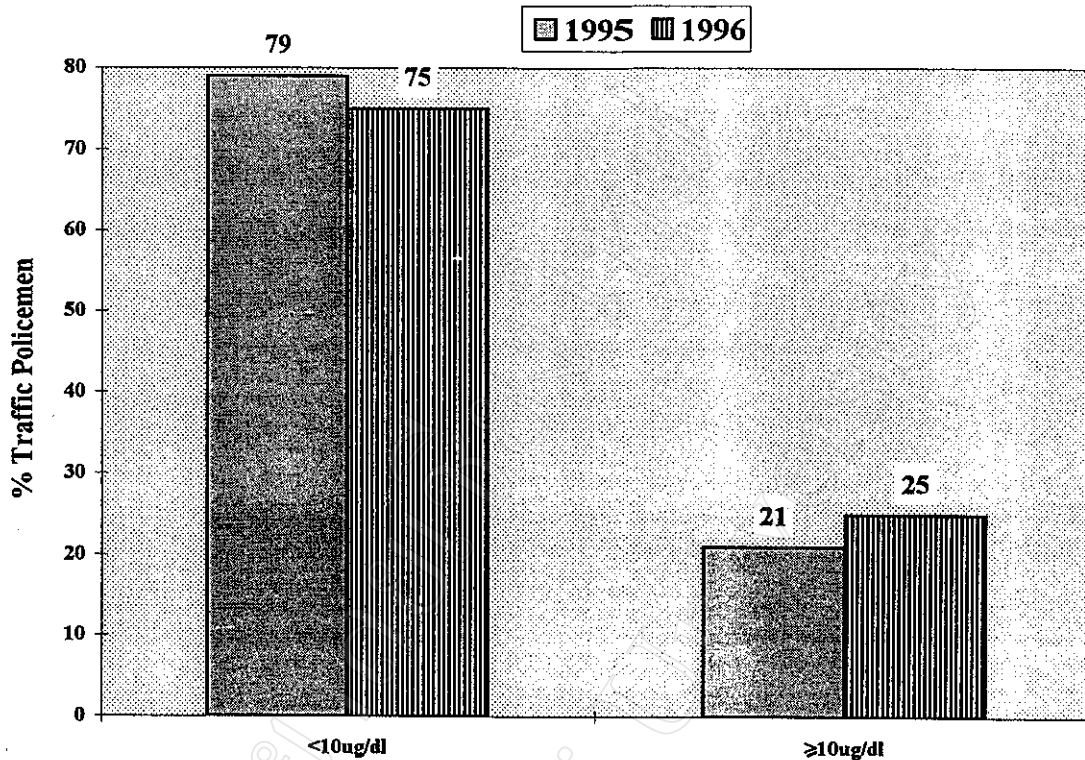
expressed by these odds ratios. However, the relative importance of the potential risk factors tested, particularly of the life style factors given, depends on the preferences of the subjects. That is, they are in principle avoidable although often by means of personal choice. Therefore, increased risks of unwarranted exposure to a large extent, will ultimately be determined by the level of awareness among the individuals concerned about Pb and its health effects, other possible sources of exposure, and most importantly, about protective and preventive measures against these exposure sources.

#### 4.4 Comparison of 1995 and 1996 PbB Levels

Blood Pb levels obtained in a previous screening (Prapamontol *et al.*, 1996) were compared with those obtained in this study in order to see the pattern of change over a one-year period following the phase out of leaded gasoline. There was no significant decline in the mean PbB levels for the two years as indicated in Table 12. Moreover, considering the sample sizes (172 and 87 for 1995 and 1996, respectively), no significant difference in the incidence of PbB levels  $\geq 10 \mu\text{g/dl}$  among participants was noted (Figure 8).

Table 12 Mean PbB Levels ( $\mu\text{g/dl}$ ) for 1995 and 1996

Year	N	Mean $\pm$ SD ( $\mu\text{g/dl}$ )	Min-Max ( $\mu\text{g/dl}$ )
1995	172	8.3 $\pm$ 3.4	2.3 - 32.9
1996	87	8.1 $\pm$ 4.6	1.1 - 21.9



**Figure 8 % Traffic Policemen with PbB Levels  $\geq 10$  ug/dl and  $< 10$  ug/dl (1995, n=172; 1996, n=87)**

This trend might have been influenced, at least partly, by the lower turnout of participants in 1996. Usually, pre-existent or intercurrent predisposition with regard to a particular condition -- in this case, Pb exposure -- among individuals may contribute some degree of bias towards the results of follow-up screenings such as this work. This is manifested in the seemingly stronger inclination of participants with relatively high PbB levels in 1995 to come for the follow-up screening in 1996. This tendency may be attributed to their concern and interest towards their present health conditions. Thus, a broader and clearer idea of how the full range of PbB levels in 1995 might have changed after a year may not be entirely observed.

Likewise, a rather slow decline in PbB levels is not entirely impossible. For instance, the Department of the Environment in the U.K. as cited by Grobler *et al.* (1992) elected to monitor the effects of the reductions in the maximum Pb content of gasoline from 1974 to 1987. Although the air levels at roadside sites had decreased by 55% in response to a 60% reduction in Pb emissions from vehicles, it was reported that no effect on PbB concentrations of adults, and a minimal decrease of 1 µg/dl in the blood of children was noted.

Similarly, Finkelman (1996) cited reports (Comision Metropolitana para la Prevencion y Control de la Contaminacion Ambiental en el Valle de Mexico, 1994; Hernandez, 1995; Palazuelos *et al.*, 1993) on the trend in the decline of PbB concentrations in schoolchildren in Mexico City. That is, after the introduction of unleaded gasoline in 1990, air Pb concentrations decreased from 1.2 µg/m<sup>3</sup> to 0.2 µg/m<sup>3</sup> in 1993. Blood lead concentrations in schoolchildren (n=2350) also went down from 16.50 µg/dl to 11.14 µg/dl in 1992. However, since 1992, the PbB level in this particular cohort of children has been reported to decline at a slower pace, showing concentrations of 9.8 µg/dl, indicating exposure to other sources.

On an environmental perspective, Wietlisbach and colleagues (1995) cited a statement by Elias (1985) that a substantial portion of airborne Pb is deposited onto soil and will persist in the ground for an undetermined length of time. From this, a substantial part can get mobilized in dusts which can float in the atmosphere for a long time and may eventually be inhaled by man. Moreover, the diminution of atmospheric Pb concentration as a consequence of the use of unleaded gasoline may likely to result in indirect and delayed effects on human exposure mainly through ingestion of contaminated food, drink, and dust (Wietlisbach *et al.*, 1995).

No significant difference in the mean PbB levels was noted among the same individuals across the two years PbB determinations were made (Table 13). However, a slight increase in the incidence of PbB ≥10 µg/dl was observed among this group

(Figure 9), and only 51 % experienced a decrease in their PbB levels. This trend indicates an apparently slow pace of decline in PbB levels after one year of using unleaded gasoline. It also suggests the possibility of exposure to other sources. At the same time, the increase in traffic volume (Appendix IV) which can, to some extent, still result to the release of Pb into the air may be a contributory factor. It must be noted that unleaded gasoline still contains not less than 0.013 g Pb/l (Wangwongwatana, 1996).

Table 13 Mean PbB Levels ( $\mu\text{g}/\text{dl}$ ) for Same Individuals for 1995 and 1996

Year	N	Mean $\pm$ SD ( $\mu\text{g}/\text{dl}$ )	Min - Max ( $\mu\text{g}/\text{dl}$ )
1995	57	7.0 $\pm$ 3.2	1.8 - 16.3
1996	57	7.5 $\pm$ 4.4	1.1 - 21.9

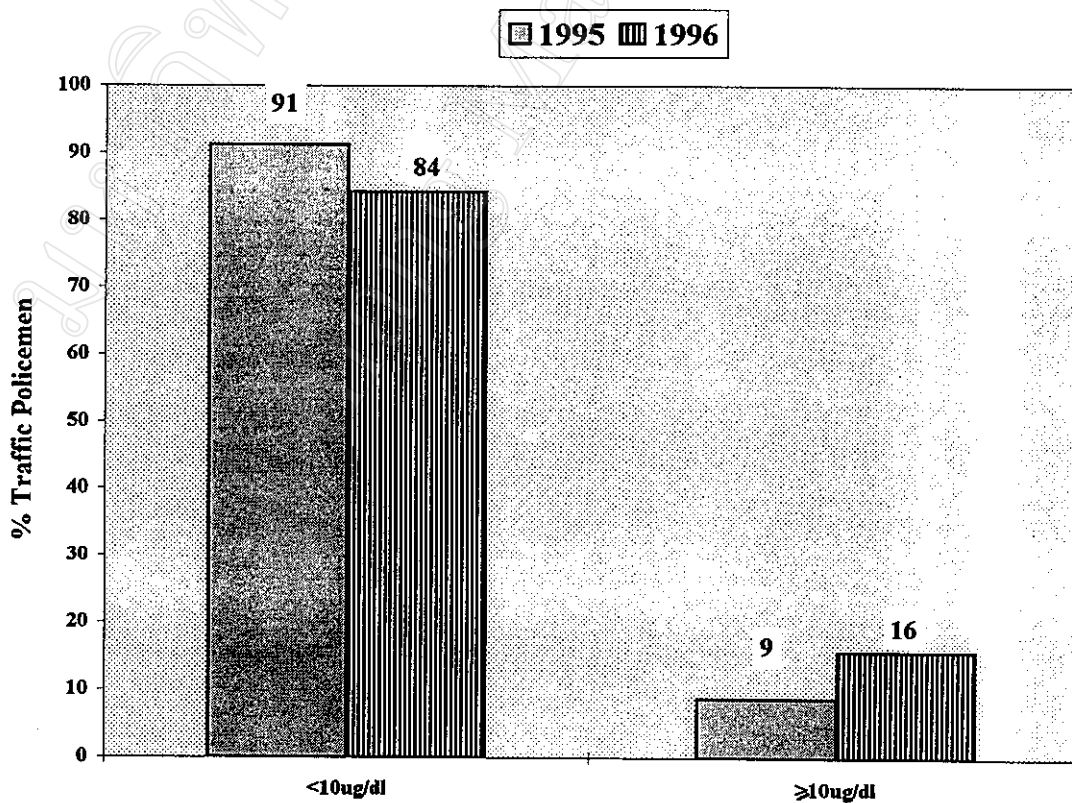


Figure 9 % Traffic Policemen with PbB Levels  $\geq 10 \mu\text{g}/\text{dl}$  and  $< 10 \mu\text{g}/\text{dl}$  Across Two Years (Same Individuals, n=57)