CHAPTER 7 – ECOLOGICAL QUALITY OBJECTIVES

7.1 Results

The metal levels of the metals in the bird feathers from the various time periods are presented in Figures 7.1 and 7.2. Metal concentrations are divided into five different time periods, i.e. 1899-1919, 1920-1939, 1940-1959, 2002 and 2005. Six distinct temporal metal bioaccumulation patterns were observed. For Al (Fig. 7.1A), Cd (Fig. 7.1C), Cr (Fig. 7.1E) and Pb (Fig. 7.2D) there were no significant differences between the first three year groups. The last two year groups were higher than the first three with the highest concentrations measured in the 2005 group. Several metals once again displayed similar concentrations for the first three year groups, but with 2002 concentrations higher than 2005. Metals that followed this pattern were Co (Fig. 7.1D), Fe (Fig. 7.2A), Mn (Fig. 7.2B) and Zn (Fig. 7.2F). There was a significant difference between the Zn levels from 2002 and 2005. Nickel (Fig. 7.2C) and Sr (Fig. 7.2E) followed the same pattern with a decrease in the levels from the first group to the third group. Once again the 2002 concentrations were higher than the 2005 concentrations. Although there were differences among the year groups, the difference were not significant. The metal levels for Cu (Fig. 7.1F) were mostly the same for all the year groups with the highest levels measured in the 1940-1959 group.

The levels of As (Fig. 7.1B) were more than a thousand times higher in the museum specimens than in the field specimens. There was a significant difference between 1899-1919 and all the other groups, except 1920-1939. There was also a significant difference between 1920-1939 and 2002 and 2005. The 2005 group was also significantly lower than the 2002 group. The highest value was recorded for the 1920-1939 year group and the lowest for the 2005 year group.

Based on the multivariate analysis, two distinct groupings can be distinguished (Figure 7.3 A and B). The group I consists of the 2002 and 2005 year groups.

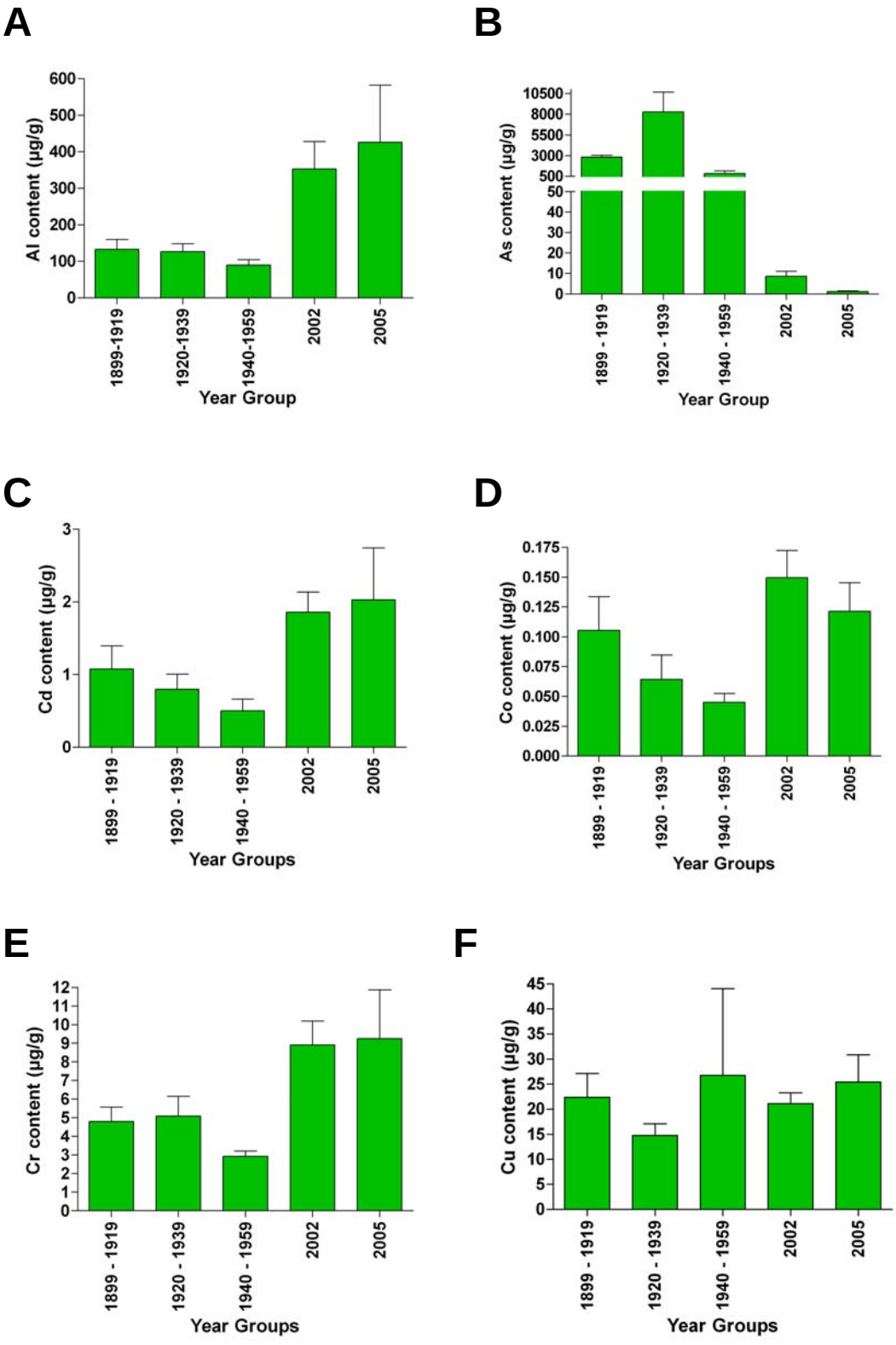


Figure 7.1 The levels of Al (A), As (B), Cd (C), Co (D), Cr (E) and Cu (F) for the various year groups.

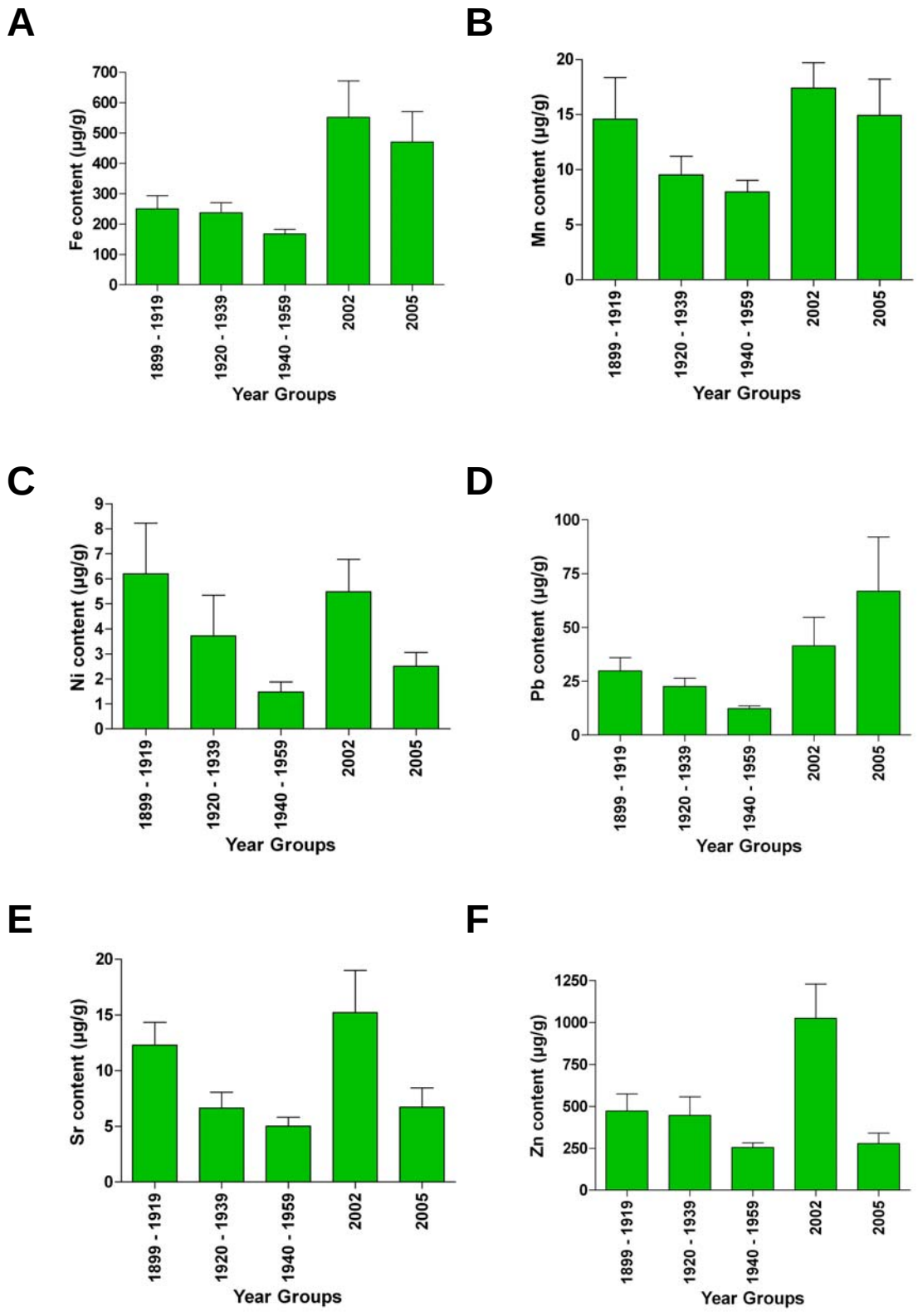
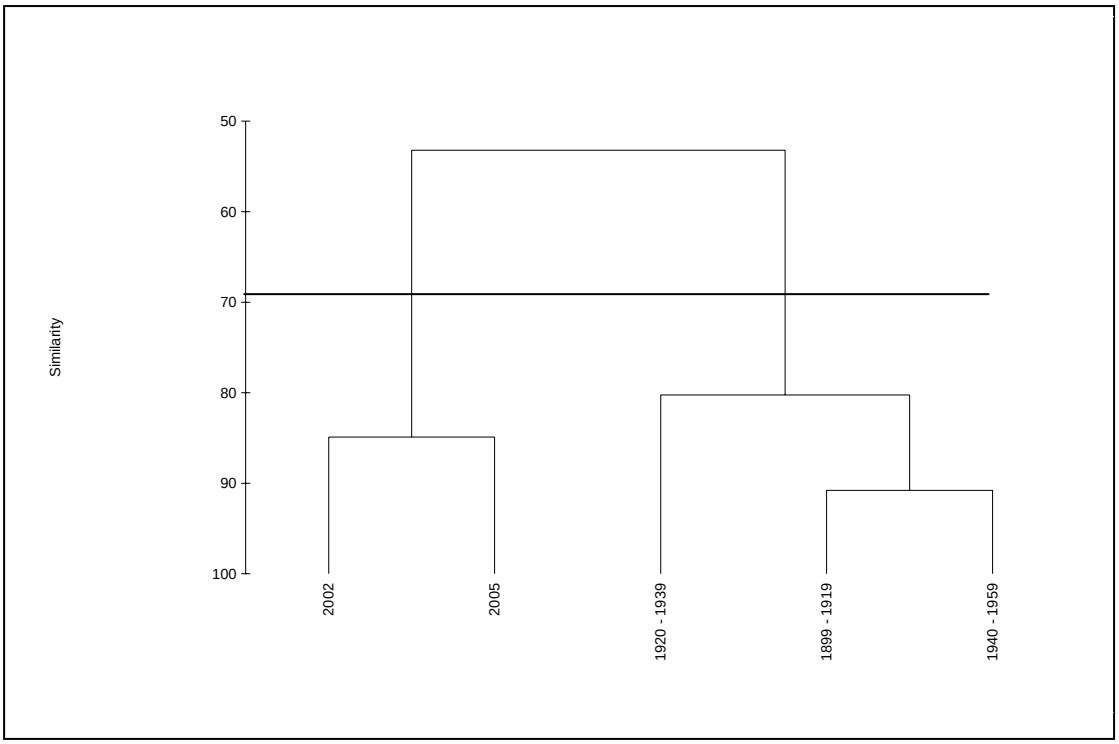


Figure 7.2. The levels of Fe (A), Mn (B), Ni (C), Pb (D), Sr (E) and Zn (F) for the various year groups.

A



B

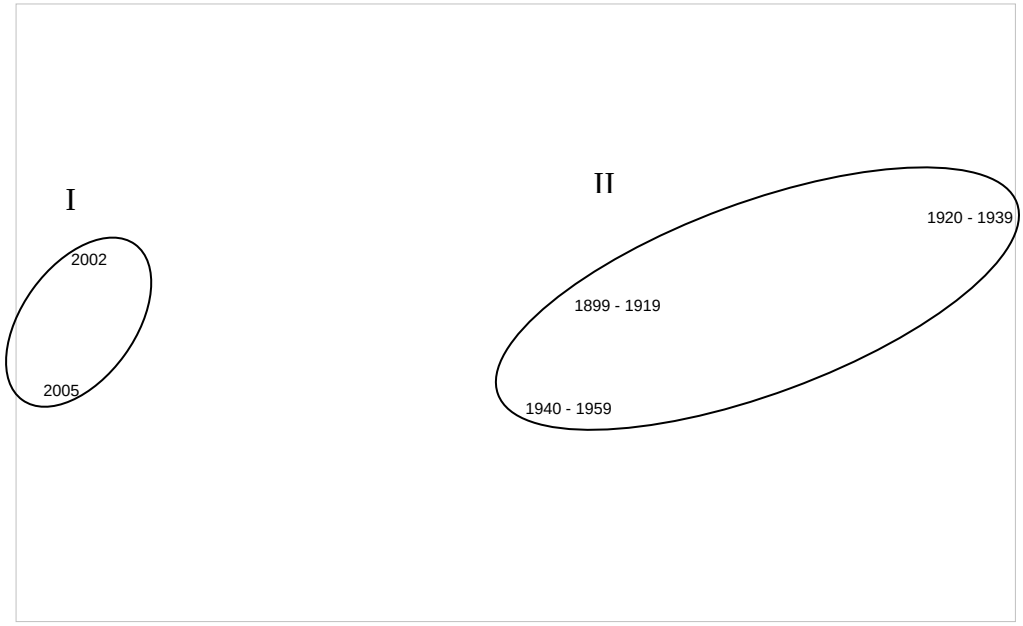


Figure 7.3 Bray-Curtis Cluster (A) and MDS (B) plots of the metal bioaccumulation in feathers of weavers from different time periods between 1899 and 2005. Similarity (70%) groups are indicated on the figure.

The other group (II) consists of the 1899-1939, 1920-1939 and 1940-1959 year groups. In other words, group I is the field specimens and group II the museum specimens. For the averaged data the stress value of 0.01 was obtained, indicating that the ordination is an accurate description of the temporal bioaccumulation patterns (Clarke and Warwick, 1994). It can clearly be seen that the museum specimens are different from the field collected specimens. They generally have lower levels of metals, except for As. For most metals there is an increase with time in the metal content. This increase is mostly not significant.

Using feathers from specimens collected from the Transvaal Museum between 1899 and 1919, the EcoQOs were determined for the three weaver species for the province of Gauteng, South Africa. For Current Levels the data from Barberspan were excluded as this falls outside of Gauteng. The resulting Current, Reference and Target Levels are summarized in Table 7.1.

Table 7.1 Ecological Quality Objectives of selected heavy metals for three weaver species in Gauteng, South Africa. Red highlighted blocks indicate those metals where the Current levels exceed the EQO Target Levels.

EcoQO Metric	Metal	Current Level (µg/g)	Reference Level (µg/g)	Target Level (µg/g)[a]
The level of selected heavy metals in the feathers of three weaver species (Ploceidae) in Gauteng, South Africa	Al	406.244	133.163	199.744
	Cd	2.115	1.075	1.613
	Co	0.138	0.105	0.158
	Cr	9.64	4.793	7.190
	Cu	25.11022	22.374	33.560
	Fe	515.045	249.974	374.960
	Mn	16.727	14.589	21.883
	Ni	4.051	6.199	9.299
	Pb	59.538	29.887	44.831
	Sr	12.536	12.293	18.440
	Zn	738.849	472.147	708.220

[a] Target Levels are calculated as not more than 50% of the Reference Levels.

As can be seen in Table 7.1, the Current Level of about half of the metals are above the EcoQO. The current levels of these metals are highlighted in red backgrounds. The Current Level for Ag and Al is more than twice the EcoQO, whereas those for Cd, Cr, Fe, Pb and Zn were also higher than their respective EcoQOs. Sr, Co, Cu and Mn were all lower than their EcoQOs. Ni was more than half of the EcoQO. The EQO for As could not be determined, as the museum data could not be used.

7.2 Discussion

Although the EcoQOs in the North Sea have only been set for organic contaminants and mercury, all the Current Levels for the North Sea were higher than the EcoQOs (ICES, 2003). In this study the Current Levels for several metals is higher than the Target Level. The data from the museum specimens could not be used to determine the Reference and Target Levels for As, due to the fact that before about 1970 the birds were preserved with Arsenic soap (pers. com. Tamar Cassidy[1]). The Reference and Target Levels would thus not reflect the true levels of As. It is thus important to keep in mind the chemicals that are used during the preservation of the birds. This was also the case with other studies where museum specimens were used (Burger, 1993). Burger (1993) also gives examples of where the analysis of museum specimens together with specimens from the field gave valuable data on the trends in metal pollution. Thus the EcoQO for As should be derived based on the Current Levels and evaluated against these levels in future.

For most metals there is an increase from 1899 to 2005. This increase is however not significant. Although the increase is not significant, care should be taken where the Current Level is higher than the EcoQO. For these metals the levels in other environmental compartments, e.g. the water or in other organisms, should be determined to see if there is indeed a risk of metal exposure. The metal content in the water can be compared with the allowable levels for metals according to the South African Water Quality Guidelines. If the metal concentrations in the water exceed the

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guideline values then the feathers may act as a warning system and should be incorporated into biomonitoring programmes where possible.

The Current Levels of Al and Zn are very high. It is a lot higher than the Al and Zn levels in Great Tits feathers from polluted sites in Belgium (Janssens *et al.*, 2001; Eens *et al.*, 1999). The Target Level was also mostly higher than these values, except for the level of Al in the feathers form Blue Tits from the Canary Islands. These islands were however of volcanic origin and have natural high Al content (Eens *et al.*, 1999). The Current and Target Levels for Zn, although high, were lower than the levels of Cu in the feathers of Black-billed Magpies near Zinc smelter in Poland (Dmowski, 1999).

The Current Level of Cd was similar to Cd levels at sites the furthest away from a pollution source in feathers of Great Tits in Belgium (Janssens *et al.*, 2001) and in the feathers of Black-billed Magpie in Poland (Dmowski, 1999). The Current Level was lower than polluted sites in Belgium for tits, but higher than the reference sites in the study. The Target Level was also higher than the reference sites (Eens *et al.*, 1999).

Both the Target and Reference Levels of Co and Mn are similar to the levels of Co and Mn in the feathers from Great Tits at sites with "medium levels" of pollution (Janssens *et al.*, 2001). Both the Current and Target Levels of Cr are much higher than any levels recorded in the feathers of tits in Belgium (Eens *et al.*, 1999; Janssens *et al.*, 2001) and Black-billed Magpies in Poland (Dmowski, 1999). The Current and Target Levels of Cu were higher than levels in the feathers of tits at most sites in Belgium, but not as high as the most polluted sites (Eens *et al.*, 1999; Janssens *et al.*, 2001). They were also not as high as the levels in the feathers of Black-billed Magpies from polluted sites in Poland (Dmowski, 1999). The Current and Target level for Fe and Ni were a lot higher than the highest levels in Great Tit feathers recorded from a polluted site in Belgium (Janssens *et al.*, 2001). The Current and Target levels for Pb were in the medium range of Pb levels in feathers of tits in Belgium (Eens *et al.*, 1999; Janssens *et al.*, 2001). They were also a lot lower than the levels in the feathers of Black-billed Magpies from industrial areas in Poland (Dmowski, 1999). The Current and Target levels for Sr were a bit higher than the levels recorded in the feathers of Sand martins in Hungary (Vallner *et al.*, 2000).

Care should be taken when developing the Target Values so that they are not too stringent or lax. This can be done by comparing them with data from other regions. As was mentioned above, even the Target Levels for Al, Fe, Zn and Ni are higher than values recorded at polluted sites in other studies. For Ni the Reference Level is also high and the Current Level is lower than the Target Level. This could indicate that although the levels are high, there has been no serious increase over time. In other cases the Target Values may be very low in comparison with other studies. Since there are now real rules when constructing the EcoQOs, they can be changed to reflect the reality of what is going on in the particular region. Even if the Target Levels are very high or very low, they can still be of use. If the Current Level is higher than the Target Level, it shows that there has been an increase over time in the level of the particular metal. This indicates that further investigation is then needed to determine the severity of the problem and any future problems that may arise.

By comparing the levels with data from other studies and taking the relationship of the Current Level with the Target Level into account, the metals can be classified into priority groups (Table 7.2). Group A consists of metals that have high metal levels and where the Current Level is higher than the Target Level. Group B consist of metals where the level of the metals is in the medium range, but the Current Level is higher than the Target Level or the level of the metal is high, but the Current Level is lower than the Target Level. Group C consists of metals where the level of the metals is medium and the Current Levels are lower than the Target Levels. The aim of this priority classification is to determine which metals are pollution risks and need priority in research. Group A has the highest priority, followed by Group B and Group C has the lowest priority.

Table 7.2 Priority groups for the metals based on the level of the metals and the relationship between the Current and Target Levels

Group A	Group B	Group C
Al	**Cd**	**Co**
Cr	**Cu**	**Mn**
Fe	**Ni**	**Sr**
Zn	**Pb**	

7.3 Conclusion

The use of museum specimens to develop EcoQOs is very important, but care should be taken with several aspects. The preservation method of the feathers might influence the results. It is also important to have a large enough sample size. The samples should also be relevant. The EcoQOs should also be compared to data from other areas, to see whether they are realistic or not. The EcoQOs can be a valuable tool in monitoring the levels of heavy metals and can be an invaluable part of the environmental laws and guidelines of an area.