Environmental zoning for service life prediction of building components in Malaysia

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Abstract. Interactions between building materials and environment are very complex. More often than not, deterioration of building component is due to environmental loads with the result of reducing its durability. The environmental loads are less overlooked or underestimated in early design phase. Objective of this study is to distinguish the difference of environmental load for different area in Malaysia. The environmental data consist of climate and pollution data which extracted from the Malaysia Meteorology Department's data bank. From this study, six different environmental zones in Malaysia are distinguished. There are different characteristic of environmental parameters found where some of them dominant to others. This information can assist the engineer to justify the use of different technology, material or construction method in construction industry.

1. Introduction
The surrounding environment condition influenced the deterioration process of building materials. Corrosion is one of the common deterioration resulted by this complex interaction of materials and the nature. The environmental load is described as the deterioration agent from atmosphere (i.e. the emission of gaseous pollution, acid deposition and the acidity of rain water) and its local climate (i.e. the relative humidity, temperature and amount of precipitation). Those agents will accelerate the deterioration process. Degradation can be subjected by behaviour or dreadful conditions but the terminology of deterioration is more on worsening or weakening of particular object. In this study the work deterioration will be used as an expression of a process to decline the performance or the aging process that lower the quality and performance of particular building components.

The amount of pollutant agents in the atmosphere and its significant effect to accelerate the deterioration process need to be studied. Together with the climatic factors which differentiate the characteristic of degradation processes of building materials in different zone can be determined. It will help in understanding the effect of local environmental factors to the deterioration of the building components.

2. Methodology
Historical data have used in this study. It consisted of air pollution data and climatic data. The data was recorded from 17 main measurement stations located in peninsular Malaysia. The data from each measurement stations were recorded by Malaysia Meteorology Department (MMD). For the purpose of this study, data that extracted from the MMD data bank were the monthly weather report which record the received rainfall, temperature, humidity and air pollution data. The pollution data are in the form of wet fall out (WFO). In the tropics, the total amount of acid that return to the earth through
precipitation accounts for only half and the other half is deposited in dry form compare to the northern hemisphere, the total amount of wet deposition for chloride is higher than sulphate and nitrate [1, 2]. For this study deposition of salt ion of chloride (Cl\textsuperscript{-}), sulphate (SO\textsubscript{4}\textsuperscript{2-}) and nitrate (NO\textsubscript{3}\textsuperscript{-}) were used. The selections of these salt ions is based on its prominent and different sources from where it was emitted. There are locations without environmental data. Its dispersion generated in the form of GIS maps to determine each deposition level from the area which have no measurement station. These maps are generated using Inverse Distance Weighing (IDW) method. The IDW method can efficiently apply and it has reliable computational process [3].

3. Analysis and discussion

The data that used to generate the GIS map was based on measured by JMM for ten years measurement (1996 - 2005). The Klang Valley and south of Johor were experiencing lowest level of pH. During north-east monsoon season the east coast area has slightly higher pH level. The increasing level of pH was leaded by highly concentration of sulphate that dissolved in rainwater to perform acidic precipitation. The level of pH in south of Johor was decreasing during north-east monsoon. The high amount of received rainfall washed-out the concentration of pollutant in the atmosphere.

Generally the northern and east peninsular received rainfall with pH between 4.8 and 5.2 while the other parts of the peninsular received rainfall with pH between 4.4 and 4.8. The areas that experience high levels of acidity were located in and around Klang Valley and southern part of Johor. These areas are rapid growth centers and industrialized with high population density. These areas were examined received rainfall with pH between 3.8 and 4.9. Figure 1 shows the monthly level of pH and the acid deposition of SO\textsubscript{4}\textsuperscript{2-} and NO\textsubscript{3}\textsuperscript{-} in industrial area. Level of pH for industrial area is influenced by gaseous pollutant of SO\textsubscript{2} and NO\textsubscript{2} in the atmosphere. It was examined by the fluctuation concentration of SO\textsubscript{4}\textsuperscript{2-} and NO\textsubscript{3}\textsuperscript{-}. Level of pH was become lowest follow by the increase of concentration of SO\textsubscript{2} and NO\textsubscript{x}. Level of pH and temperature were the variable of oxidation reaction time for SO\textsubscript{2}. Xu have stated in his study on deposition of SO\textsubscript{4}\textsuperscript{2-} in East Asia that when the level of pH in the cloud during condensation less than 4 the dissolved H\textsubscript{2}O\textsubscript{2} was predominant in oxidizing the gaseous form of SO\textsubscript{2} to SO\textsubscript{4}\textsuperscript{2-}. Ozone (O\textsubscript{3}) was the predominant oxidant agent when the level of pH greater than 5 and cause the reaction of oxidation 10 times faster [4].

![Figure 1. Monthly acid deposition of nitrate, sulphate and its relationship with level of pH in the rain water](image-url)
Chloride (Cl\textsuperscript{-}) has been used widely as a tracer in the hydrologic cycle since it was often considered not influenced from any chemical weathering, mineral formation or biological process. The primary source of chloride in the atmosphere was the sea salt ion which was generated by wind stress on the ocean surface that burst at the surface and emit sea water aerosols into the atmosphere. The additional source probably included HCl emission from coal fired generating stations and HCl from sea salt dechlorination. High concentration of Cl\textsuperscript{-} was found on coastal area.

The east coast of Peninsular Malaysia was experienced with highly concentration of Cl\textsuperscript{-} during north-east monsoon season. The spread coverage of Cl\textsuperscript{-} in the precipitation was leaded by the wind blow of the two monsoon seasons. Figure 2 shows the average concentration of Cl\textsuperscript{-} for ten years measurement. From the figure, it was examined that east coast of Peninsular Malaysia experienced with higher concentration of Cl\textsuperscript{-}. Using the IDW interpolation in the GIS maps, it has shown that the monsoons seasons extended the dispersion of Cl\textsuperscript{-} to the land area. During the south-west monsoon season, wind blow from the Indian Ocean and the west coast area experienced with higher Cl\textsuperscript{-} concentration.

![Figure 2. Average Chloride for 10 Years in Peninsular Malaysia](image)

Based on the level of concentration of different level of environmental and pollutant data generated in GIS map and analysed, the zoning of the environmental load was determined. Figure 3 show the different level of concentration and range of maximum and minimum values for each salt ion deposition and level of pH from received rainfall. It is shown that sulphate which was dissolved in rainfall and deposited as wet fall out seems predominant in industrial area and it increased the acidity of rain water to the pH range under 5. Nitrate as result mostly from combustion of vehicles is experienced fairly same range for all zones. Chloride is a dominant pollutant agent for the coastal area and island especially during monsoon seasons.
4. Conclusion

The ranges of the concentration of pollutant are slightly different for different environmental zoning. Some of pollutant depositions are found dominant for particular zone. The clear determination of characteristic of area will give different view and understanding on how a building should be designed and built. Thus, it can be good information for designer and engineer to justify their design and to propose new technology to produce better quality building.

References

[1] Ch. Anatolaki, and R. Tsitouridou Atmospheric deposition of nitrogen, sulfur and chloride in Thessaloniki, Greece, 2010 Journal of Atmospheric Research, 85 413–428
[2] Chotimongkol, L. et. al. Deterioration By Atmospheric Pollutants Of Historical Places In Thailand 2003 Proceeding of the EUROMAT 2003
[3] Cole, I.S. et. Al. Mechanism of Atmospheric Corrosion in Tropical Environments 2000 Marine Corrosion in Tropical Environments, ASTM STP 1399, American Society for Testing and Materials, West Conshohocken, PA.
[4] Xu Y. The Investigation of the Mechanism of Sulphur Deposition in Asia, 1998 UMI Microform 9834537: University of Iowa, USA, Ph.D. Thesis.