Innovative Systems Design and Engineering
ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)
Vol.4, No.11, 2013


# Optimal Choice of Defluoridation of Okpoko Water Scheme using Decision Tree Analysis

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**Abstract**
This paper addresses issue of excessive level of fluoride in drinking water supplies as a major problem in Okpoko industrial area of Onitsha. Thus, a rationale of low cost defluoridation methods is proposed in this area of no alternative water source except boreholes. Decision theory analysis is used to determine the lowest maintenance cost as optimal solution.
**Keywords:** Optimal solution, defluoridation, decision theory,infiltration

## Introduction

Industrial advanced fluoride, as studied by Bhargava and Killedar(1991) is mainly contributed through runoff and infiltration of chemical materials and liquid waste from industrial sources. More so it heavily contributes fluoride in the surface and sub-surface water around the vicinity.

Abida et al (2007) noted in their Toxic fluoride Arsenic contaminated ground water, that only a small fraction of waste water from thermal power plant is generally being recycled due to inadequate capacity of employed treatment plant. Therefore seepage of this contaminated water increased the fluoride content in the surface and sub-surface water around the thermal power plants much above the permissible limit of 1.5mg/l.

This study aims at determining the cost-effective of reducing the excessive undesirable levels of fluoride in drinking water supply which are serious problems in Okpoko industrial area of Onitsha metropolis (Baker, 2006). The major source of fluoride in this area is considered to be the dissolution of waste products from industries which are rich in fluoride. Virtually every borehole in this area has an average concentration of fluoride between 10 – 15mg/l in her water table. The reduction of the concentration to the barest minimum in necessary and inevitable (Brown and Sobsey, 2007).

The maximum amount of fluoride in a drinking water is regulated at 1.5mg/l (WHO 1997) and more than that is linked to dental and skeletal fluorosis (Abida et al 2007). However, some possible control options to protect the fluorosis problem may include provision of alternative source of water, blending with low fluoride containing water, provision of bottle water, treatment of water supply at source and at the point of use (Brown and Sobsey, 2007). In consideration of the above options which have no permanent solution, it is paramount important to defluoride at 1.5mg/l which is WHO standard by choosing a more technical option among three low cost option of ASL, AB, and AC (Hall and Dracup, 1979).

Therefore, the aims of objectives of the water scheme proposal are:

i) To choose one out of three low cost water defluoridation methods and maintenance.
ii) To determine the technical and economic feasibility in the community.
iii) To develop community support system that make defluoridation sustainable.

## Methodology

### Study Area

Okpoko is one of the suburbs of Onitsha Metropolis, with a population of 205020 according by National Population Commission in 2006, Many industries, such as Texiles, Plastics, Confectioneries, Brewery etc. are sited in this suburb. Okpoko is located between latitude 6.1667°N and 6.2311°N, longitude 6.7833°E and 6.8777°E,and bound in West is River Niger. Below is map of Onitsha locating Okpoko industrial area.


Fig. 1: Map of Onitsha showing the study area - Okpoko

**Systems Analysis**

In relation to feasibility study of defluoridation method/maintenance, justifying the technical cost and social sustainability in the context of nationwide economic problem is very essential (Major and Lenton, 1979). The technical feasibility study may focus on factors such as availability of material, cost for initial construction and for operation and maintenance treatment efficiency, simplicity of the method and the quality of treated water.

In the Civil and Environmental Systems Engineering,ReVelle(2004) et al presented a multi-objective theory with regard to perspective one of the potentially practicable methods which can be selected based on decision tree method of system analysis

This method enables the community which is the decision maker to examine all possible outcomes whether successful or unsuccessful in the maintenance cost of the water scheme, (Sharma, 2010).

The table below is a basic approach of Bayesian decision theory considering the three methods with cost of execution and maintenance. Finally, the optimal action and solution (Hamdy, 2011).

**Table 1: Statistical Data**

| Method | Type Event | Prior probability | Cost execution | Type action | Posterior probability |
|---|---|---|---|---|---|
| | | | | | |
| ASL | High concentration | 0.3 | 2,500,000<br>-816,000 | Successful<br>Unsuccessful | 0.7<br>0.3 |
| | Low concentration | 0.7 | 980,000<br>-420,000 | Successful<br>Unsuccessful | 0.6<br>0.4 |
| ABC | High concentration | 0.3 | 780,000<br>-820,000 | Successful<br>Unsuccessful | 0.9<br>0.1 |
| | Low concentration | 0.7 | 940,000<br>-320,000 | Successful<br>Unsuccessful | 0.4<br>0.6 |
| AC | High concentration | 0.2 | 630,000<br>-700,000 | Successful<br>Unsuccessful | 0.7<br>0.3 |
| | Low concentration | 0.8 | 600,000<br>-100,000 | Successful<br>Unsuccessful | 0.5<br>0.5 |

ASL = Chemical precipitation by Aluminium Sulphate and Lime
ABC = Adsorption by Bone Char
AC = Adsorption by Clay

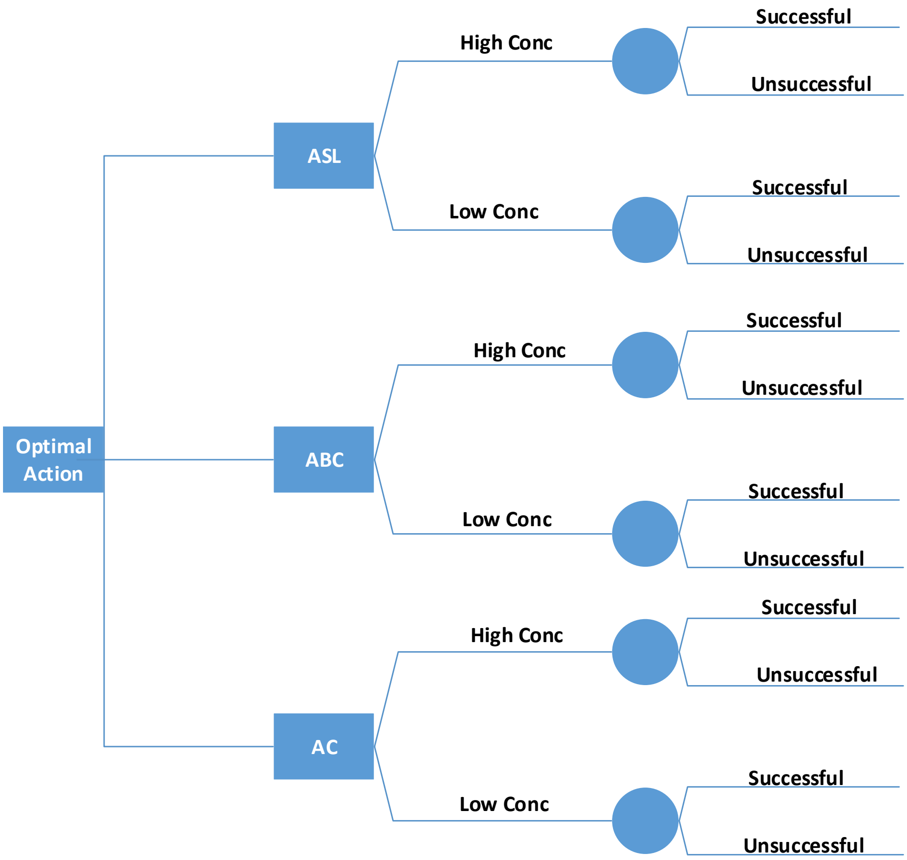


Fig. 2: Decision Tree Analysis

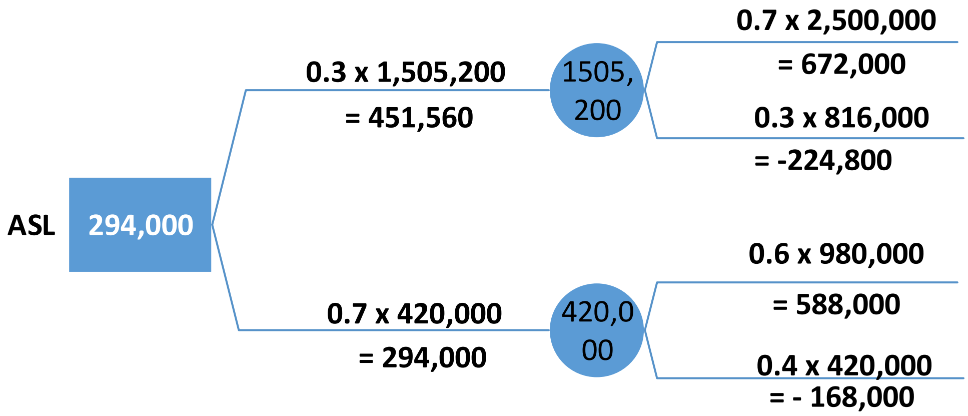


Fig. 3: Decision Tree for ASL

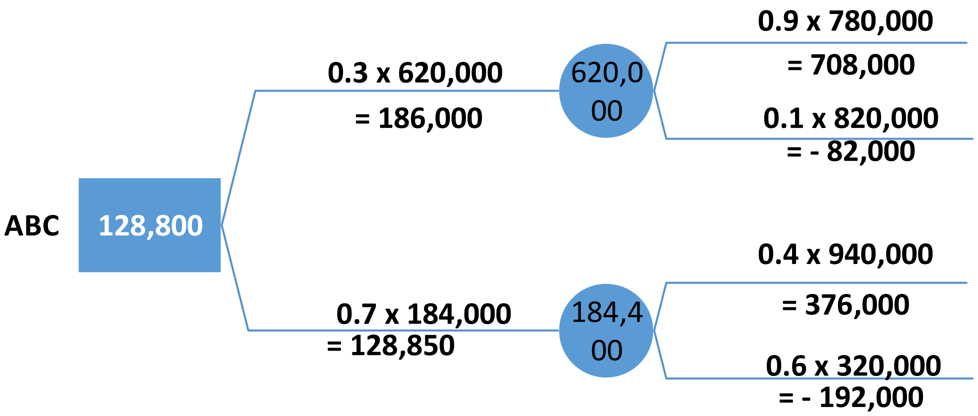


Fig. 4: Decision Tree for ABC

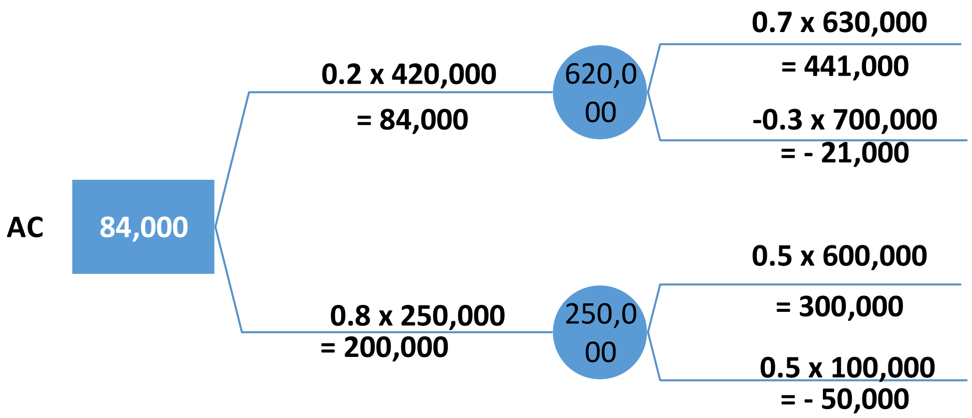


Fig. 5: Decision Tree for AC

**Discussion**

The capital cost of executing this scheme is generally expensive mainly for aluminium sulphate method as the establishment of the plant requires more technical and scientific inputs. On the other hand, capital cost for the method based on adsorption onto bone char and clay is relatively lower because the defluoridation unit can be built using locally available low cost material. Also the cost of chemical material transportation, fuel and lubricant in running this system is quite expensive.

More so, the cost for aluminium sulphate and lime is generally more expensive than the cost of clay and bone char. However, the process of preparing clay and bone as treatment media is labour intensive (Bhargava and Killedar, 1991).

**Conclusion**

The decision theory analysis displaces the logical relationship between the three low-cost defluoridation decision and identifies the time sequence in which various actions and subsequent events occur (Gupta and Hira, 2012). This requires the decision-maker to examine all possible outcomes, whether successful or unsuccessful. Observation shows that aluminium sulphate and lime addition process can remove the fluoride concentration to a level below 3mg/l at optimum operating conditions but very expensive to maintain (Baker, 2006).

However, the adsorption processes are cheap, but clay adsorption is cheaper as clearly indicated in the decision tree analysis, where the cost of maintenance is ₦84,000 against ₦128,800 for bone char adsorption and aluminium sulphate and lime is ₦294,000.

Further more,Brown and Sobsey(2007) in their Improving HouseHold Drinking Water Quality,concluded that exposure to higher amount of fluoride can cause joint pains,restriction of mobility and possibly increase the risk of some bone fractures

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