1. Experimental investigation of the effect of **henna extract** on the swelling

of sodium bentonite in aqueous solution:

Henna is an environmental-friendly additive to stop the swelling of shale. The inhibition properties of Henna extract depends on its concentration and are quite comparable and similar with potassium chloride and polyamine . Henna extract has a lower adsorption isotherm in alkaline medium (pH = 9) compared to natural medium (acidotic) as shown in results of adsorption measurements . Adsorption of Henna extract increases sodium bentonite surface's hydrophobicity but this is weakened to a small extent in alkaline medium due to the effect of caustic soda as a pH adjustment agent.

Henna extract imparts some deflocculating properties at low concentrations (up to 0.2 mass%); yet it has good inhibition properties to sodium bentonite swelling at a concentration several times higher than that of deflocculating concentration, about 3 mass%. The hydrogen bonding between the hydroxyl group of Henna extract constituents and oxygen atoms on silica groups of sodium bentonite especially to the lawsone(2-hydroxy-1,4 napthaquinone) constituent causes the inhibition properties.

Failure of kcl- Potassium ion presence at a concentration above 1 Wt% in drilling fluids (water-based ) fails these fluids as given by mysid shrimp bioassay test (Anderson et al.,2010). High potassium chloride concentration could yield harmful effects on environment including the high costs of disposal, high fluid loss due to high clay flocculation (Zhong et al., 2011), and higher corrosion rates due to high salinity(Clark et al., 1976).

Failure of Quaternary amine salts- They have a high efficient inhibition property but a number of disadvantages including their toxicity ,fluid flocculation with high solid concentration, and incompatibility with anionic drilling fluids additives. The major constitutes of Henna extract are lawsone (2-hydroxy-1,4 napthaquinone,C10H6O3), gallic acid (3,4,5-trihydroxybenzoic acid, C7H6O5), dextrose(α − D -Glocose, C6H12O6), and tannic acid (Ostovari et al., 2009).

Amount of Henna extract adsorption on sodium bentonite using this method can be determined by the following equation (Ahmadi and Shadizadeh, 2013).

q = (m total solution\* ( co-c)\* 10−3)/msample

Hydrogen atoms from the structure of the Henna extract constituents are removed by solution of Henna extract in water, leading to a decrease in solution pH, particularly up to concentrations of 0.2 mass%. The rate of swelling of sodium bentonite in any Henna extract concentration was found to be remarkably lower than in distilled water at each time period. However, sodium bentonite still swells even though its rate of swelling is lower than that in distilled water at low concentrations of Henna extract (1 mass%). The air-water contact angle for sodium bentonite with the absence of Henna extract is 23.59° and 23.88° degrees for both natural pH and adjusted pH of 9 respectively.

The average price of powder of Henna leaves with $1/kg and is mainly an agriculture products mainly in north-western states. The results of dynamic linear swelling tests indicate that Henna extract is capable of reducing the swelling of sodium bentonite in both test temperatures of 28°C and 82°C.