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# ADSORPTION OF HEXAVALENT CHROMIUM FROM ADSORBATE USING EUCALYPTUS *(EUCALYPTUS GLOBULES*) AND SAKHU *(SHOREA ROBUSTA)* SAW DUST AS AN ADSORBENT

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## ABSTRACT

**The present work deals with the removal of chromium from adsorbate solution using of Eucalyptus and Sakhu saw dusts. The adsorbent material for removal of chromium (VI) ion using fixed double packed adsorption column. The comparative study was done with both plants saw dust, in different pH, temperature, adsorbate concentration and different adsorbate concentrations. It was also observed that the maximum adsorption shows Sakhu saw dust is 91.66% as compared to Eucalyptus saw dust at 50 g adsorbent 50 ppm adsorbate solution with 27 °C temperature and pH 6.**

**KEY WORDS :** Adsorption, Adsorbate, Column, Hexavalent chromium

## INTRODUCTION

Hexavalent chromium is a form of the metallic element chromium. Chromium is a naturally occurring element found in rocks, animals, plants, soil, and volcanic dust and gases. It comes in several different forms, including trivalent chromium and hexavalent chromium. Trivalent chromium is often referred to as chromium (III) and is proposed to be an essential nutrient for the body (Rao *et al.*, 2014). Hexavalent chromium, or chromium (VI), is generally produced by industrial processes. Chromium compounds, such as hexavalent chromium, are widely used in electroplating, stainless steel production, leather tanning, textile manufacturing, and wood preservation.The hexavalent form is 500 times more toxic than trivalent (Kowalski, 1994). It is toxic to human and affects lung, kidney, liver and abdomen (Cieslak, Golonka, 1995). The World Health Organization (WHO) recommends a maximum acceptable concentration of Cr (VI) as 2.0 mg/l in wastewater which is discharging outside. It has been reported that excessive intake of chromium by human leads to hepatic and renal damage, capillary damage, gastrointestinal irritation and central nervous system irritation (Raju and Naidu, 2013).

Adsorption is most effective method for removing Hexavalent chromium especially if combined appropriate regeneration steps. Due to this reason present work focused on low-cost adsorption process with double packed column on the biosorption capacity of Sakhu and Eucalyptus sawdust for the removal of Chromium (VI) from adsorbate solution. The effect, concentration of adsorbent, concentration of adsorbate, time of contact and temperature was also considered in a column technique.

## MATERIALS AND METHODS

**Preparation of adsorbate stock solution:** A stock solution of 500 mg/l Cr (VI) concentration was prepared by dissolving 1.41g of 99.9% potassium dichromate ($K_2Cr_2O_7$) in 1 litre distilled water. Further, 5 litres of 100 mg/L Cr (VI) concentration working solution was prepared by diluting the stock solution.

**Preparation of adsorbents:** For the preparation of adsorbents, different saw dusts Sakhu (*Shorea*

Research Scholar

*robusta*) and Eucalyptus *(Eucalyptus globules)* were collected and 50 g of each saw dusts were sun dried, grinded and sieved to fine powder (218 µ Size). Further saw dusts were treated with 1% formaldehyde in the ratio of 1:4 (w/v) and 50 mL 0.2 N $H_2SO_4$ followed by washing with distilled water and drying on hot plate at 50 °C for 4 hours with continuous stirring. The final weights of activated saw dusts were between 25 – 75g indicating 70% – 80% moisture removal.

Percent moisture loss (ML) = W/S X 100

W= weight of dried sample (g)

S= Sample weight (g)

**Column preparation for adsorption:** Lab scale Chromium adsorption column was fabricated by two columns of 4.0 cm, 6.0 cm diameter and 24.0 cm, 36.0 cm length respectively. The small column was perforated and filled with saw dust then it was fitted in large column. One inlet was provided to smaller column and outlet to larger column. The flow was regulated by flow regulator. 100 mg/l working solution was passed through the column with retention time of 40 minutes and flow rate 0.1 ml/sec.

**Chromium analysis:** The chromium concentration was analysed at 540 nm on UV-vis spectrophotometer (Labtronics, model: LT-39), using 1,2-Diphenyl carbazide as complexing agent at slightly acidic pH between 4 to 6 and temperature 25 °C, 27 °C, 30 °C, and 32 °C. Research reviews have revealed that maximum adsorption of chromium is observed at slightly acidic pH 6. In the present investigation 0.1N HCl and 0.1N NaOH were used to maintain pH. Mathematical method was used to calculate equivalent chromium ion concentration (Cr) after being adsorbed on saw dust. Further percent reduction (R%) in chromium concentration was calculated using following formula.

$$R\% = \frac{Co - Ce}{Co} X\ 100$$

R% = Percent reduction

Co = Initial concentration of working solution in mg/L

Cf = Equivalent metal ion concentration in mg/l (After being adsorbed by adsorbent)

## RESULTS AND DISCUSSION

### Effect of adsorbate concentration

Fig. 1 clearly indicated that maximum adsorption shows of Sakhu saw dust is 96.36% and eucalyptus saw dust is 83.63% at the 20 pppm adsorbate concentration. In 50 g adsorbate concentration the maximum adsorption was shown by Sakhu saw dust 92.85% and eucalyptus 87.50% at 50 ppm adsorbate concentration as indicated in graph 2. Graph no.3 represented maximum adsorption show of Sakhu saw dust 89.3% and eucalyptus saw dust 48.38% at 50 ppm adsorbate solution and 75 g adsorbent concentration. The result show more adsorption in 50 ppm adsorbate concentration at 50gm saw dust it was possible due to increasing the competition amongst chromium species for positively charged groups on surface area of saw dusts (Mishra and Shukla, 2021).

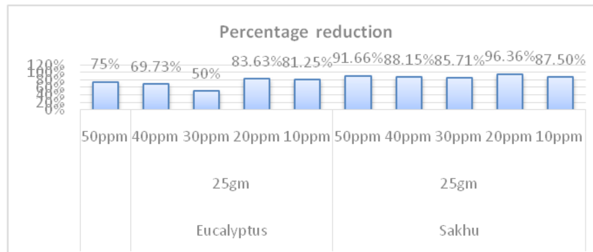


**Fig. 1.** Effect of adsorbate concentration at 25 g adsorbent at pH 6 and 27 °C

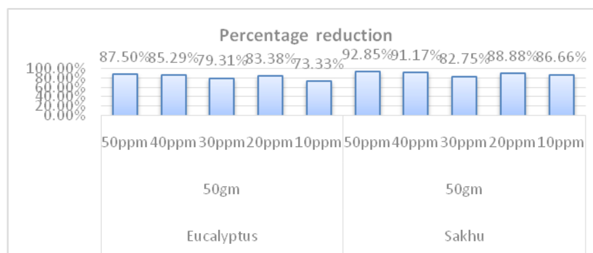


**Fig. 2.** Effect of adsorbate concentration at 50 g adsorbent at pH 6 and 27 °C

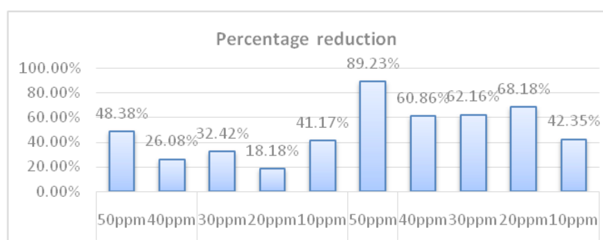


**Fig. 3.** Effect of adsorbate concentration at 75 g adsorbent at pH 6 and 27 °C

### Effect of adsorbent concentration

Figure 4 to 7 it clearly indicates that at 50g adsorbent dose the adsorption of Chromium was maximum such as Sakhu 92.85% and Eucalyptus 87.50%. The adsorption increases of adsorbent dose up to 25 g to

50 g. It may be due to availability of exchangeable sites or surface area (Thakur and Parmar, 2013; Mishra and Shukla, 2021). But further increases of adsorbent dose such as 75 g adsorbent in small column, which reduces the pore size and thereby reducing the active surface sites.

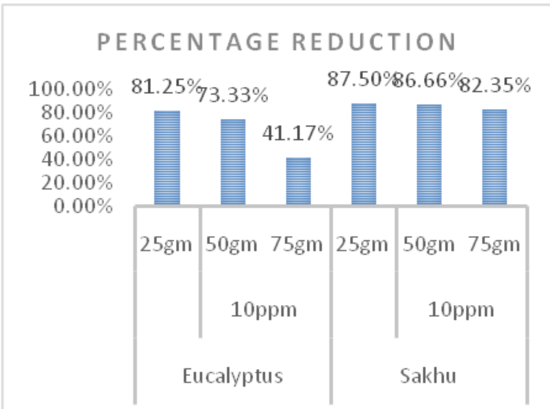


**Fig. 4.** Effect of adsorbent concentration at 10 ppm adsorbate concentration

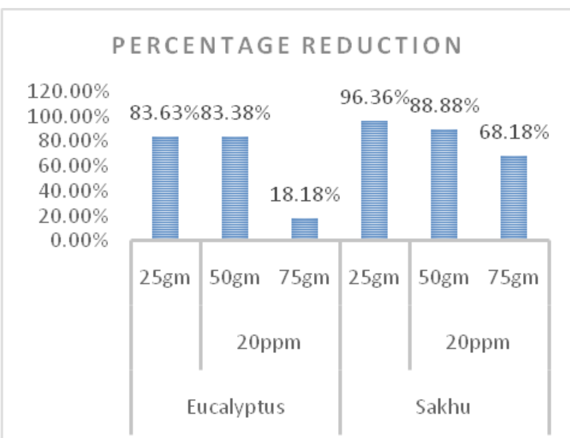


**Fig. 5.** Effect of adsorbent concentration at 20 ppm adsorbate concentration

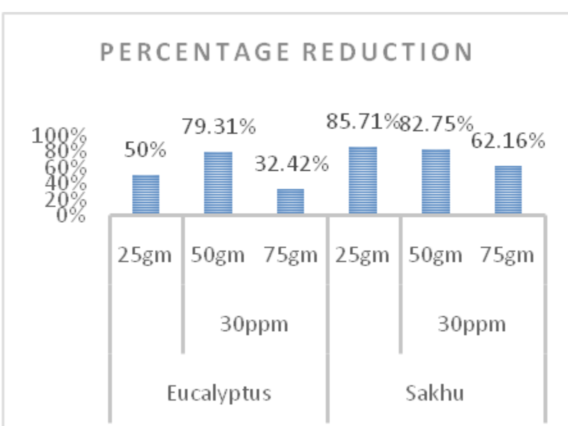


**Fig. 6.** Effect of adsorbent concentration at 30 ppm adsorbate concentration

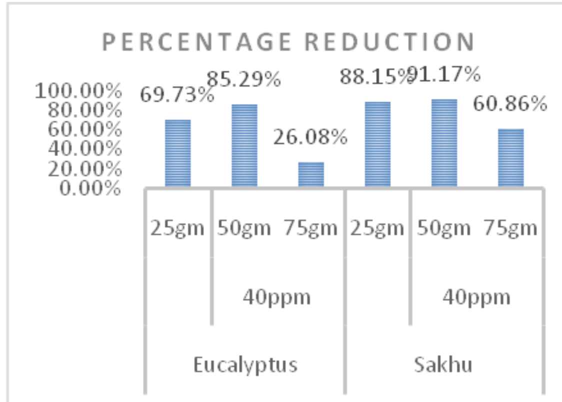


**Fig. 7.** Effect of adsorbent concentration at 40 ppm adsorbate concentration

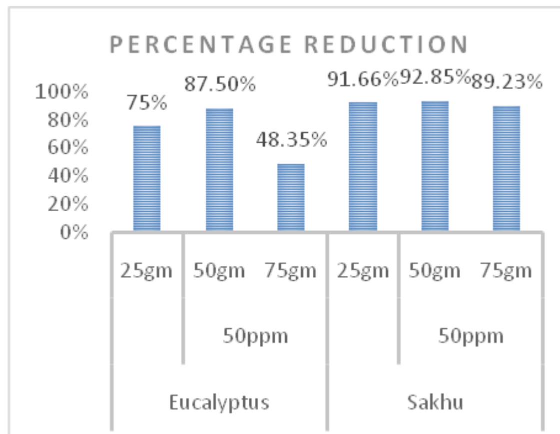


**Fig. 8.** Effect of adsorbent concentration at 50 ppm adsorbate concentration

## Effect of pH

From Figure 9 to 23 is clearly indicate that maximum adsorption shows at pH6 adsorbate solution ascompare to pH4 and pH5 adsorbate solution. Graph indicate the increasing pH capacity of

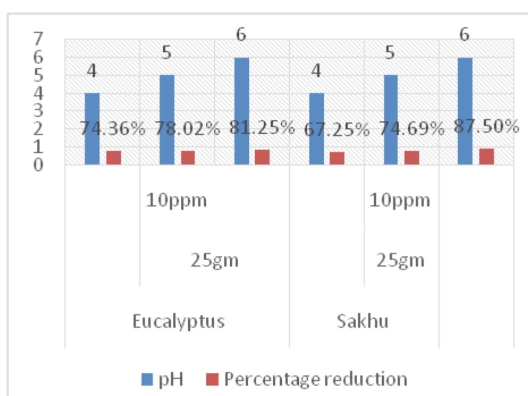


**Fig. 9.** Effect of pH at 25 g adsorbent and 10 ppm adsorbate concentration

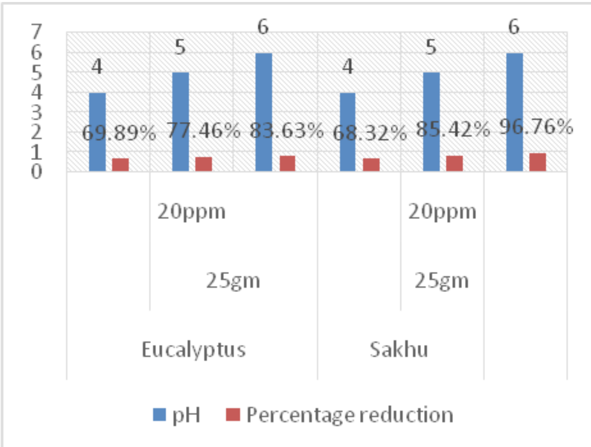


**Fig. 10.** Effect of pH at 25 g adsorbent and 20 ppm adsorbate concentration

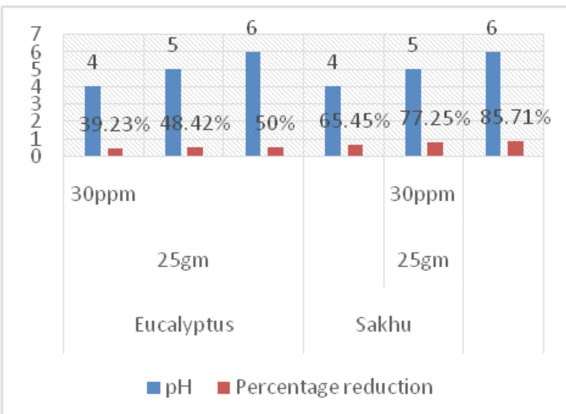


**Fig. 11.** Effect of pH at 25 g adsorbent and 30 ppm adsorbate concentration

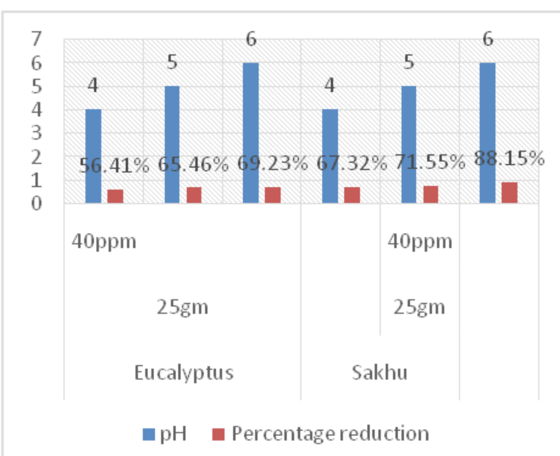


**Fig. 12.** Effect of pH at 25 g adsorbent and 40 ppm adsorbate concentration

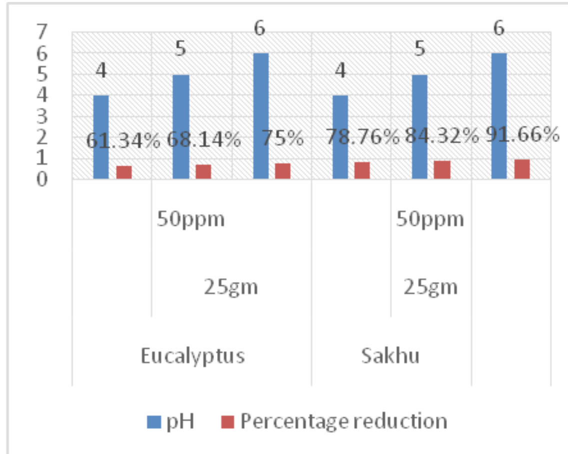


**Fig. 13.** Effect of pH at 25 g adsorbent and 50 ppm adsorbate concentration

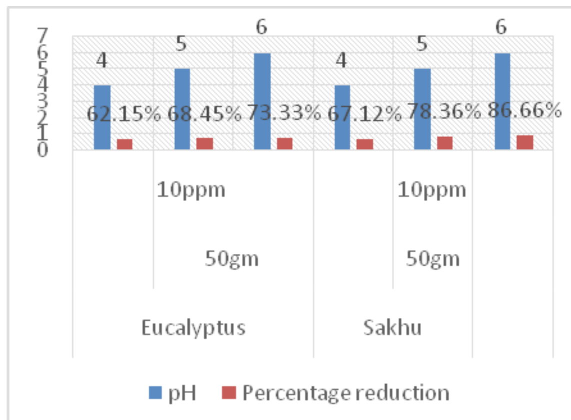


**Fig. 14.** Effect of pH at 50 g adsorbent and 10 ppm adsorbate concentration

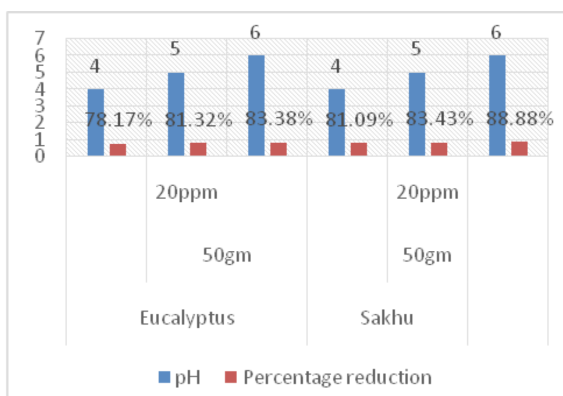


**Fig. 15.** Effect of pH at 50 g adsorbent and 20 ppm adsorbate concentration

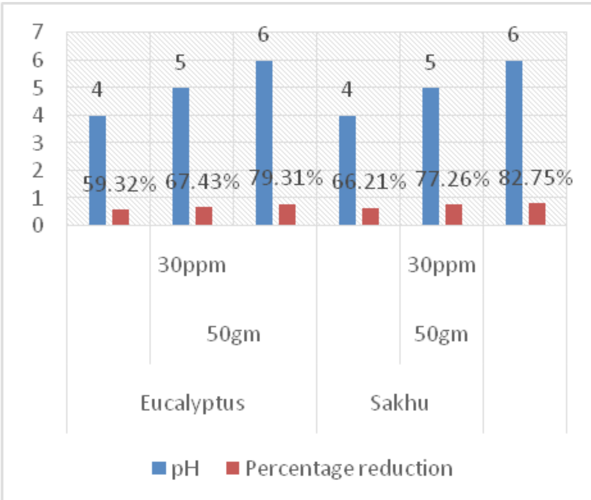


**Fig. 16.** Effect of pH at 50 g adsorbent and 30 ppm adsorbate concentration

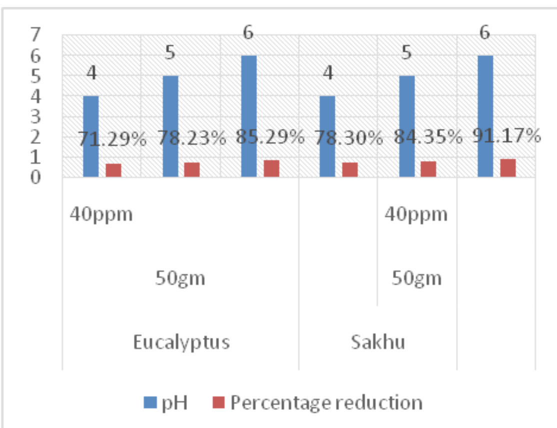


**Fig. 17.** Effect of pH at 50 g adsorbent and 40 ppm adsorbate concentration

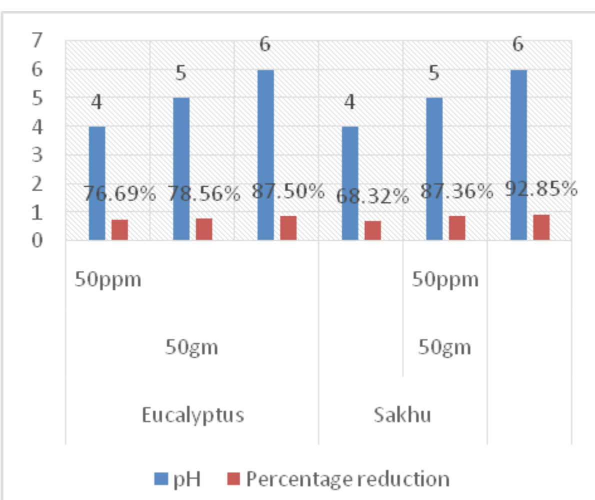


**Fig. 18.** Effect of pH at 50 g adsorbent and 50 ppm adsorbate concentration

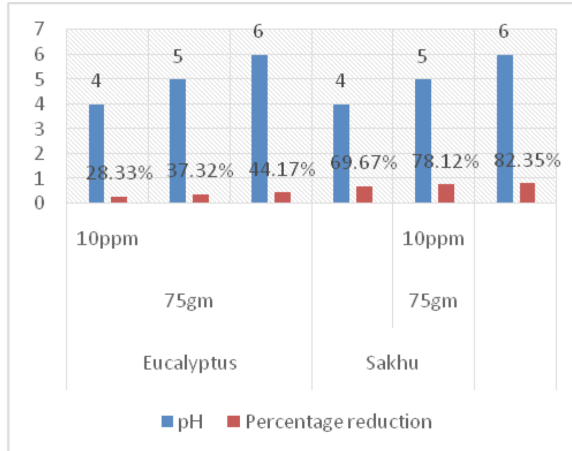


**Fig. 19.** Effect of pH at 75 g adsorbent and 10 ppm adsorbate concentration

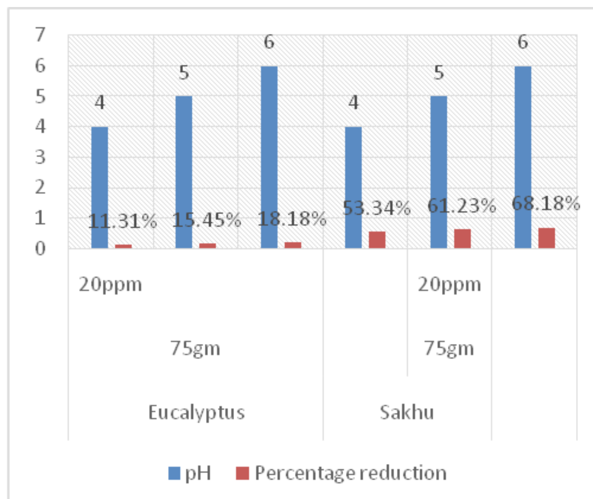


**Fig. 20.** Effect of pH at 75 g adsorbent and 20 ppm adsorbate concentration

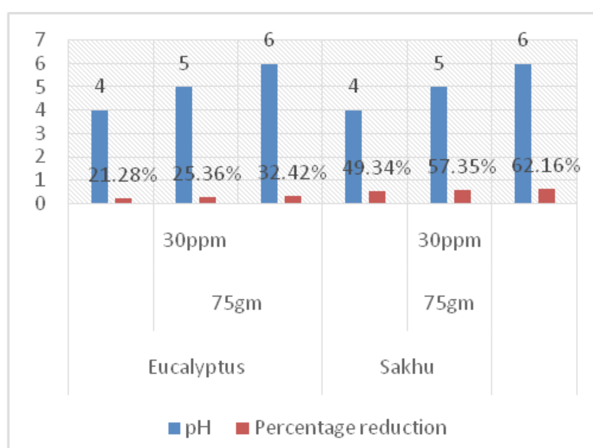


**Fig. 21.** Effect of pH at 75 g adsorbent and 30 ppm adsorbate concentration

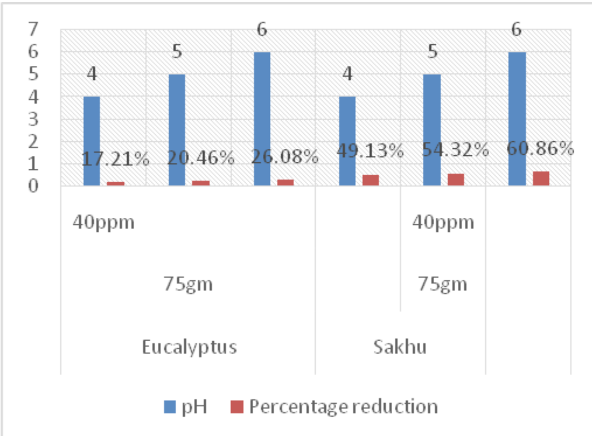


**Fig. 22.** Effect of pH at 75 g adsorbent and 40 ppm adsorbate concentration

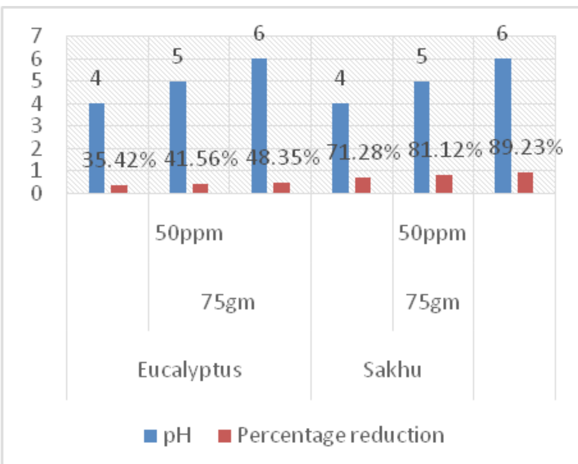


**Fig. 23.** Effect of pH at 75 g adsorbent and 50 ppm adsorbate concentration

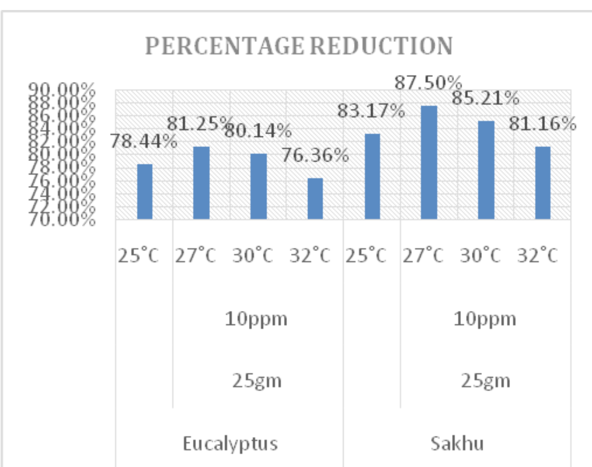


**Fig. 24.** Effect of temperature at 25 g adsorbent and 10 ppm adsorbate concentration

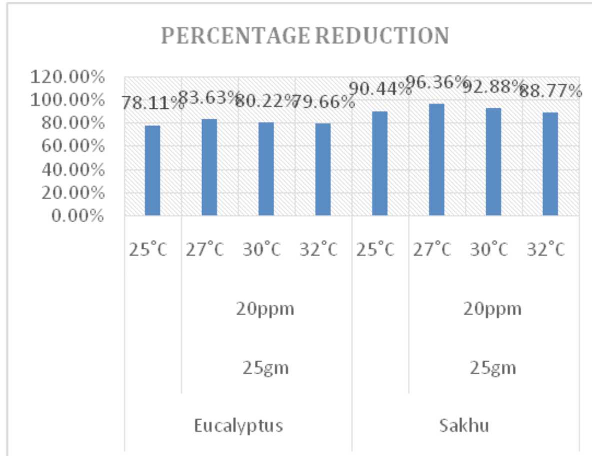


**Fig. 25.** Effect of temperature at 25 g adsorbent and 20 ppm adsorbate concentration

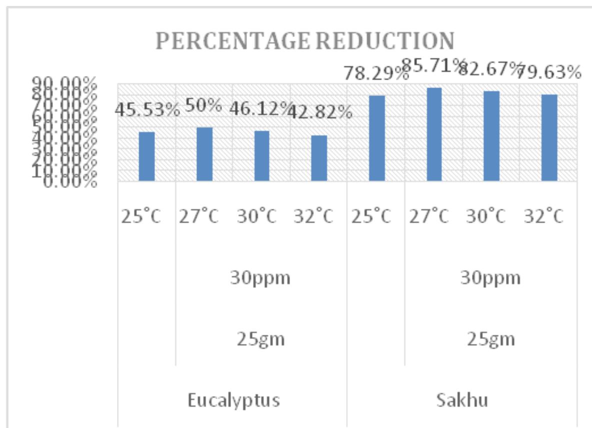


**Fig. 26.** Effect of temperature at 25 g adsorbent and 30 ppm adsorbate concentration

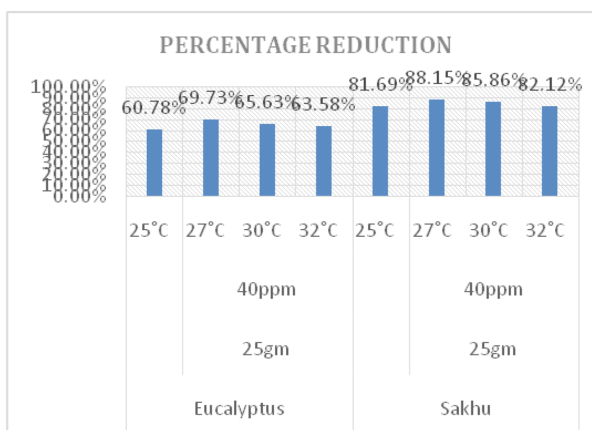


**Fig. 27.** Effect of temperature at 25 g adsorbent and 40 ppm adsorbate concentration

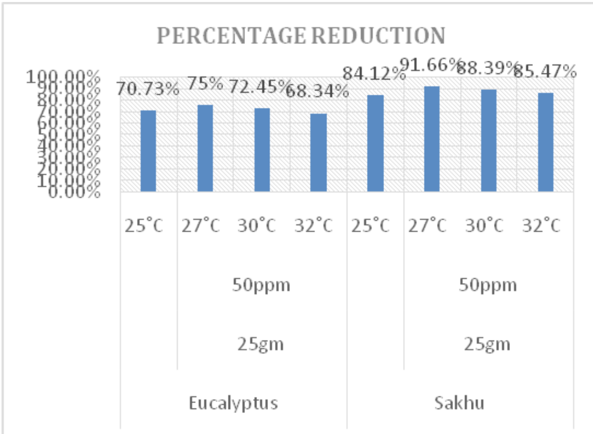


**Fig. 28.** Effect of temperature at 25 g adsorbent and 50 ppm adsorbate concentration

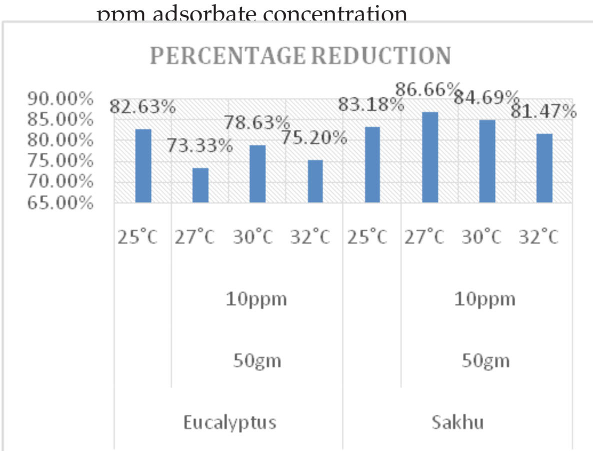


**Fig. 29.** Effect of temperature at 50 g adsorbent and 10 ppm concentration

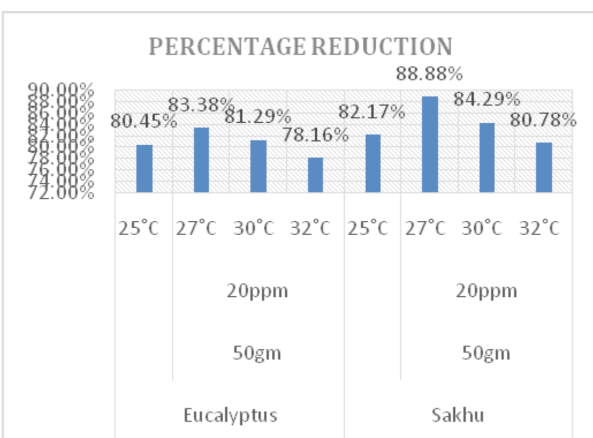


**Fig. 30.** Effect of temperature at 50 g adsorbent and 20 ppm adsorbate concentration

percentage reduction is also increases it was due to increasing chromium adsorption was observed at increasing pH value. This may be due to

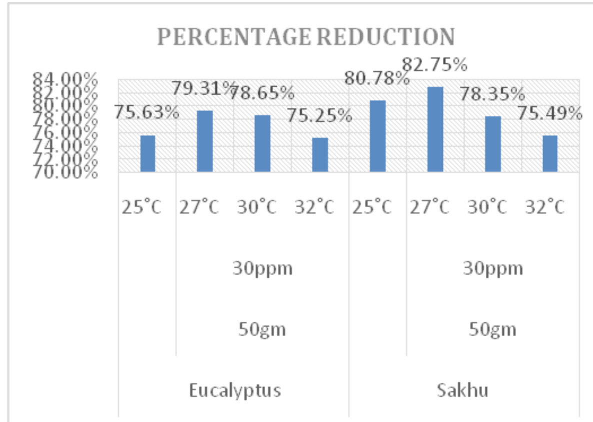


**Fig. 31.** Effect of temperature at 50 g adsorbent and 30 ppm adsorbate concentration

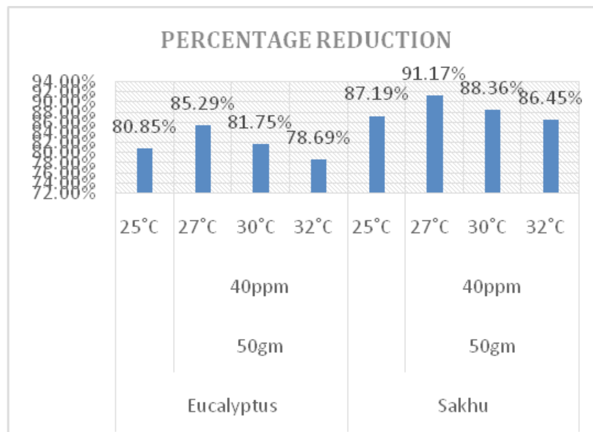


**Fig. 32.** Effect of temperature at 50 g adsorbent and 40 ppm adsorbate concentration

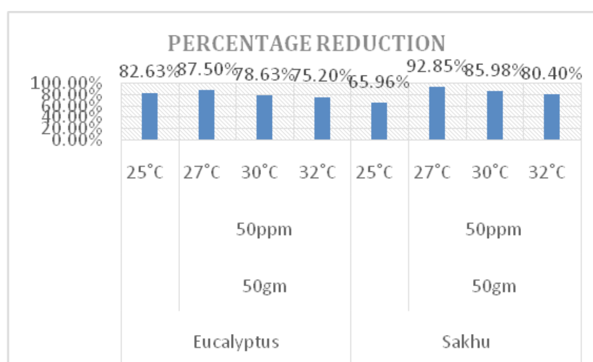


**Fig. 33.** Effect of temperature at 50 g adsorbent and 50 ppm adsorbate concentration

deprotonation of binding site which makes different functional group available for chromium binding and vice versa (Nur E Alam *et al.,* 2020; Mishra and Shukla, 2021).

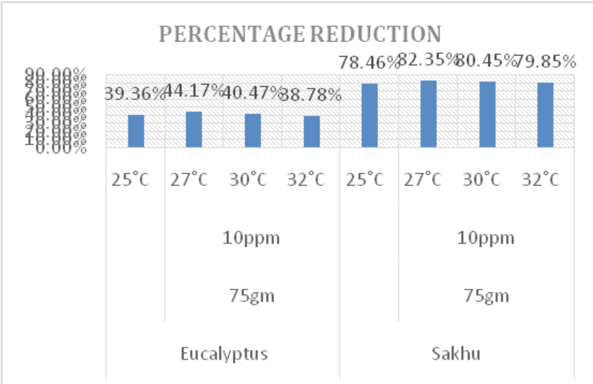


**Fig. 34.** Effect of temperature at 75 g adsorbent and 10 ppm adsorbate concentration

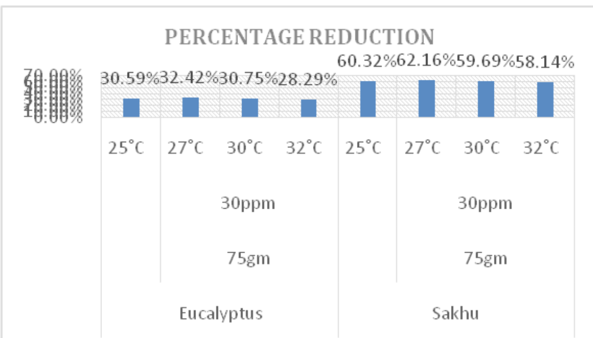


**Fig. 35.** Effect of temperature at 75 g adsorbent and 30 ppm adsorbate concentration

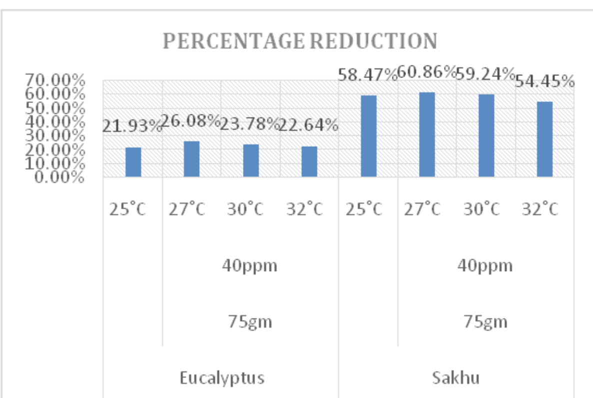


**Fig. 36.** Effect of temperature at 75 g adsorbent and 40 ppm adsorbate concentration

### Effect of temperature

Figure no. 24 to 38 clearly indicate that maximum adsorption shows at 27 °C adsorbate solution in every saw dusts as compare to 25 °C, 30 °C and 32 °C adsorbate solution. Graph clearly indicated optimum removal of chromium at 27 °C by different saw dust, below and above this temperature the

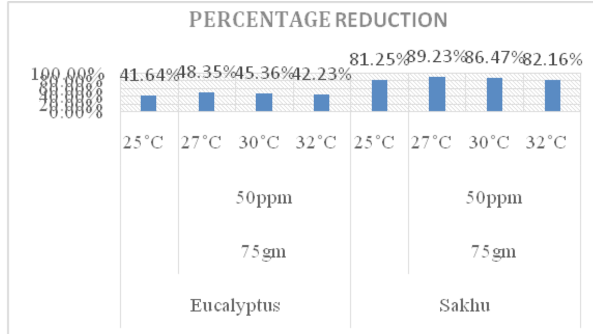


**Fig. 37.** Effectof temperature at 75 g adsorbent and 50 ppm adsorbate concentration

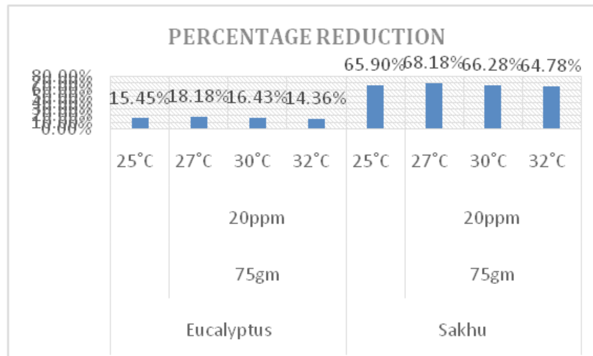


**Fig. 38.** Effect of temperature at 75 g adsorbent and 20 ppm adsorbate concentration

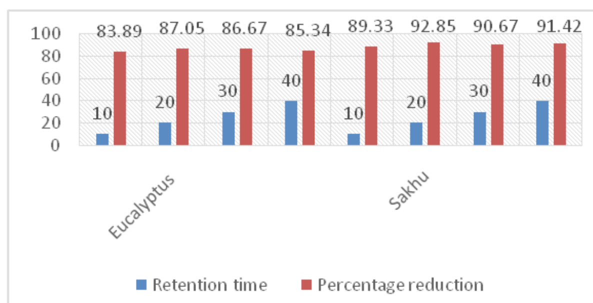


**Fig. 39.** Effect of retention time at 50 g adsorbent and 50 ppm adsorbate concentration at pH 6 with 27 °C temperature.

adsorption capacity of saw dusts decreases, it causes to enhancement in the adsorption capacity was due to the chemical interaction between adsorbate and adsorbent, creation of some new adsorption site or increased rate of intraparticle diffusion of chromium ions into the pores of the adsorbents at 27 °C. (Sciban *et al.*, 2007; Mishra and Shukla, 2021).

### Effect of retention time

Figure 39 it was clear that the more adsorption shows at 20 minutes retention times as compared to 10, 30, and 40 minutes. Initially increasing of retention time, the adsorption increases up to 20min. but further increases of retention time the rate of adsorption almost gets stabilized. It was due to initial abundant availability of adsorption sites, which is frequently occupied by chromium, resulting reduced availability of adsorption sites at increased retention time (Shukla and Mishra, 2021).

## CONCLUSION

The adsorption of hexavalent chromium from adsorbate solution (10-50ppm) using Sakhu (*Shorea robusta*) and Eucalyptus (*Eucalyptus globules*) which arevery efficient low-cost and eco-friendly process. Results indicatedSakhu saw dust was more adsorption show 92.85% as compare to Eucalyptus which was highest 87.50% at 50ppm adsorbate concentration, 50 gm adsorbent concentration, pH 6, retention time 20 minutes, and 27 $^{o}$C temperature.

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