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Are Frozone's Powers Feasible?

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Abstract
Frozone, a friend of the Incredibles family in the 2004 film '*The Incredibles'*, has super powers that enable him to produce and manipulate vast amounts of ice. In the film, it is stated that he does this by using water molecules from the air or from his body. Frozone is seen to freeze a man in the film using his powers, and it was calculated that 2.53×10^{-7} kg of water would be required to do this. It was also investigated whether it would be possible for him to acquire this amount of water from his body or from the air in Chicago. It was calculated that Frozone would be able to freeze 2.15×10^{8} and 1.67×10^{14} people utilising water molecules from his body and the air in Chicago respectively, therefore concluding that his powers are feasible.

Introduction
In the 2004 film '*The Incredibles*', Frozone (Lucius Best) is a friend of the Incredible family. Similarly to the Incredibles, Frozone also has superpowers and has, on multiple occasions, used them to help the family. He has the ability to control ice by producing it from his fingertips, and to do this he uses water from the air or from his body. Without enough water present around him, his ice-making abilities are hindered.

This paper investigates whether Frozone's powers are feasible by calculating how much water would be required to freeze a person by encasing them in ice, and if this is possible by utilising water molecules from his body or from the air.

Amount of water
The amount of water required to freeze a person was calculated first. It was assumed that Frozone was freezing an average man, of height, H, 174 cm and mass, M, 83.6 kg [1, 2]. The surface area, A, of this man was calculated using the Mosteller formula (Equation 1 [3]).

$$SA_{man} = \sqrt{\frac{M \times H}{3600}} = \sqrt{\frac{83.6 \times 174}{3600}} = 2.01\ m^2 \quad (1)$$

The area of a water molecule was calculated next, where the water molecule was modelled as a sphere with a radius of 1.375×10^{-10} m [4]. The surface area was calculated using Equation 2, and was calculated to be 2.38×10^{-19} m^2.

$$A_{sphere} = 4\pi r^2 \quad (2)$$

These calculated area values were used to calculate the number of water molecules required to freeze the man;

$$\frac{2.01\ m^2}{2.38 \times 10^{-19}\ m^2} = 8.45 \times 10^{18}\ water\ molecules$$

This value was used to calculate the mass of this number of water molecules (Equation 3), using the molar mass of water as 18.02 gmol^{-1} and Avogadro's number, N_A.

$$mass = \frac{Mr}{N_A} \quad (3)$$

$$mass = \frac{18.02\ gmol^{-1} \times 8.45 \times 10^{18}}{6.022 \times 10^{23}\ mol^{-1}}$$

$$= 2.53 \times 10^{-4}\ g$$

$$= 2.53 \times 10^{-7}\ kg$$

Sourcing the water

Assuming a maximum total body water percentage for Frozone of 65%, and his mass of 83.6 kg, he would have 54.34 kg of water in his body [5]. With this, he would be able to freeze 2.15×10^{8} average males.

The number of people Frozone could freeze using all of the water in the air of Chicago was then calculated. To do this, the mass of water molecules in the air in Chicago was calculated, assuming that *The Incredibles* was set in Chicago [6]. The volume of Chicago was taken to be 6.67×10^{9} m^3, calculated using the ground area of Chicago as 606.1×10^{3} m^2 and the height as the height of the troposphere, 11×10^{3} m [7, 8]. The mass of the air, m, in Chicago was then calculated to be 8.17×10^{9} kg using Equation 4, where ρ_{air} = 1.225 kgm^{-3}.

$$m = \rho \times V \qquad (4)$$

Using average temperatures and humidity for Chicago, 10°C and 67% respectively [9, 10], it was calculated that that there would be 2.35g water vapour per pound of dry air. Therefore, for 8.17×10^{9} kg of air in Chicago, there would be 1.80×10^{10} pounds of air, meaning 4.23×10^{7} kg of water vapour.

This can be compared to the previously calculated value of the mass of water Frozone requires to freeze a person, 2.53×10^{-7} kg. It shows that Frozone would be able to freeze 1.67×10^{14} people using water vapour in the air in Chicago. This is significantly greater than Earth's population as of March 2017 [11].

Conclusion

2.53×10^{-7} kg of water would be required for Frozone to freeze a man of average dimensions. As it is stated in the film that Frozone sources the water to form ice from his body or from the air, the feasibility of this was investigated. It was calculated that using water from his body, he would be able to freeze 2.15×10^{8} people, and using water from all of the air in Chicago he could freeze 1.67×10^{14} people. This suggests Frozone's powers are feasible, and that if he had the ability to harness and freeze the water, there would be plenty for him to utilise.

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