IJIAET International Journal of Innovative Analyses and Emerging Technology

| e-ISSN: 2792-4025 | http://openaccessjournals.eu | Volume: 1 Issue: 5

# Studying the Effect of Interior Scrubber Hydraulic Resistance on Cleaning Efficiency

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**Annotation:**

The paper examines the effect of inertial scrubber hydraulic resistance on industrial secondary gas cleaning in the wet method on the cleaning efficiency. In experimental studies, gas velocity, fluid flow, and injector hole diameter were selected as variables. In experimentsIntermediate increase in cleaning efficiency at minimum and maximum values of liquid consumption is 6.7%, gas flow rate during hydrogen-fluoride gas cleaning is 17.32 m / s and cleaning efficiency of the device in 30% aqueous solution of calcium technical soda is 97.42% detected.

**Keywords:** inertial scrubber, hydraulic resistance, cleaning efficiency, fluid flow, fluid layer, injector, mass transfer.

**Introduction:**

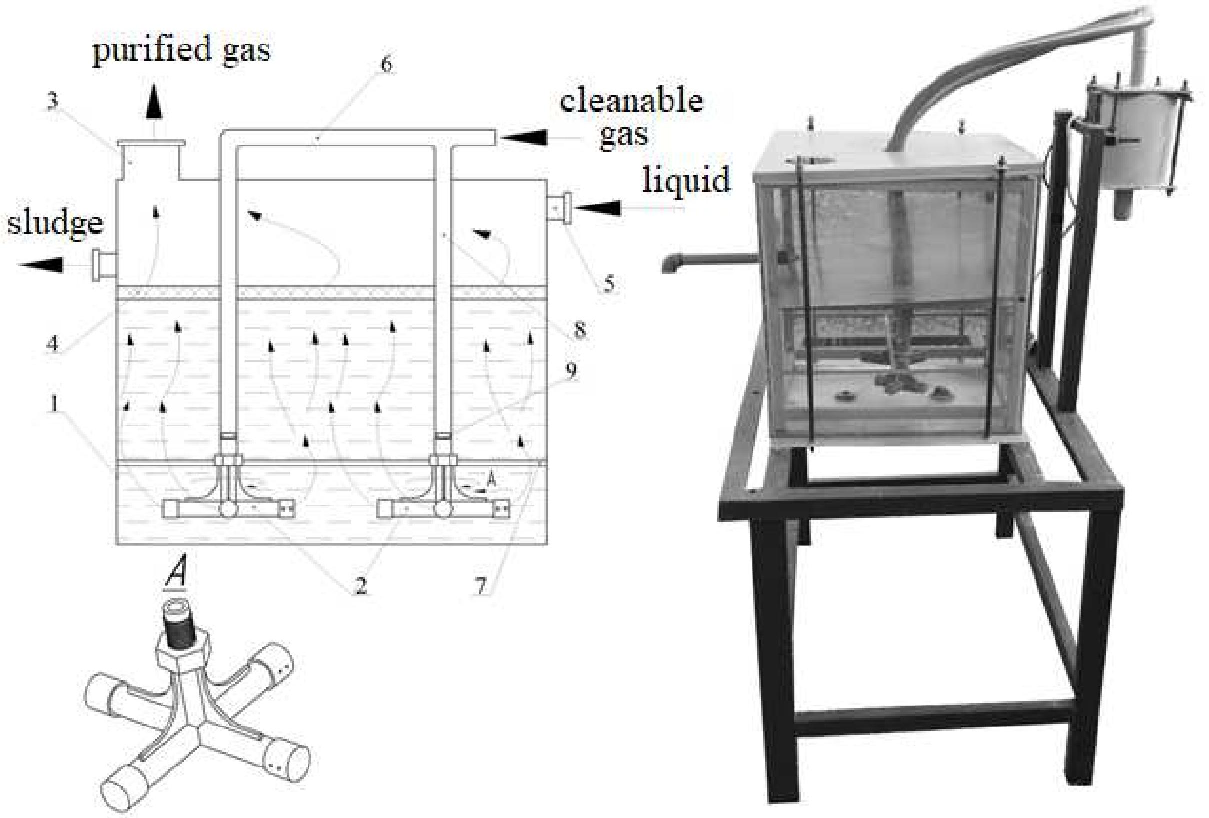
The designs of wet dust and gas cleaning devices vary, and the most common of these devices are scrubbers. The main advantage of scrubbers over other wet-method devices is that the waste water is less likely to clog the device pipes and the sludge formed during cleaning will stick to the device walls. In addition, it is highly effective in the purification of gases with aggressive temperatures and high flow rates [1,2,3].

This method also has specific disadvantages, for example, the energy consumption for cleaning is higher than the dry method, which has to recycle dust and gases absorbed into the liquid medium. In addition, the efficiency of scrubbers used in industry does not always meet the requirements of existing environmental standards in terms of PDK levels of harmful substances released into the atmosphere. This is mainly due to external influences loaded on the device and the high addition of dust and secondary gases to the gas flow.

Therefore, it is necessary to use new effective methods or external energy effects to increase the probability of dust and secondary gases colliding with liquid droplets [4,5]. For example, a liquid used to purify gases at high temperatures evaporates. But it is not used to purify gases from steam. If ways and means of using this steam are created, the energy spent on cleaning can be reduced by 50%. In addition, most devices currently in use come into contact with the fluid at a specific contact element. This, in turn, requires setting a finite value of the gas velocity and the amount of particle in the stream. As a result, mass transfer processes slow down or complete mass transfer becomes difficult. In this regard, it is more efficient to identify and apply the method of inertial transfer of gases directly to the internal environment of the liquid. Currently, a lot of research is being done in this area [3, 6,7,8,9 etc.].

**Research objects:**

Based on the above, a structural analysis of the constructions of prospective devices currently used and presented in research, their advantages and disadvantages was carried out, and on the basis of the obtained results a design scheme of inertial scrubber for dust and gas cleaning [10] (Fig. 1) was developed. the hydraulic resistances of the device depending on the gas velocity were determined experimentally. [7].




1-Scrubber body; 2- Secondary gas distribution syomnik; 3-Purified gas outlet pipe; 4- Panjarali nasadka; 5 Fluid transmission pipe; 6-Clean gas pipeline; 7-Tirgak; 8 Reference pipe; 9- Gas conical plug; 10 Liquid slime.

**Figure 1. General view of an inertial scrubber**

**Research results:**

This paper examines the effect of hydraulic resistance on cleaning efficiency. The following parameters of the variables in determining the hydraulic resistance of the device, the gas velocity $\upsilon_g$ = 7 ÷ 25.6 m/s, the intermediate step increased by an average of 4.5 m/s, the gas consumption $Q_g$ = 150 ÷ 330 $m^3$/h, the intermediate step by an average of 70 $m^3$/h increased to, the diameter of the nozzle hole $d_t$ = 2; 3 and 4 mm, fluid flow $Q_{suy}$ = 0.141; 0.168 and 0.178 $m^3$/h, the inert gas density was selected as $\rho_g$ = 1.29 kg/$m^3$ (for air). The temperature for the water and gas system was set at 200S ± 2, taking into account the influence of the external environment during the experiments.

The results of the experiment were processed using an EXM and the relationship of hydraulic resistance to different values of variable factors was investigated in the absence of fluid supply to the device. Based on the results of the experiments, a comparison graph of the dependence of hydraulic resistance on the gas velocity was constructed. (Figures 2; 3 and 4).

The data in Figures 2;3 and 4 show that the variable factors increased the gas velocity $\upsilon_g$ = 7 ÷ 25.6 m / s with an intermediate step averaging 4.5 m / s, and the gas consumption $Q_g$ = 150 ÷ 330 $m^3$ / h with an intermediate step averaging 70 $m^3$. / h was observed to increase from $\Delta P_{sb}$ = 221 Pa to $\Delta P_{sb}$ = 2959 Pa for $d_t$ = 4 mm. While the intermediate step averaged $\Delta P_{sb}$ = 400 Pa, it was observed that for $d_t$ = 3 mm, $\Delta P_{sb}$ = 252 Pa increased from $\Delta P_{sb}$ = 3381 Pa. The intermediate step averaged $\Delta P_{sb}$ = 450 Pa and was observed to increase from $\Delta P_{sb}$ = 316 Pa to $\Delta P_{sb}$ = 4227 Pa for $d_t$ = 2 mm. The intermediate step averaged $\Delta P_{sb}$ = 600 Pa.

ISSN 2792-4025 (online), Published under Volume: 1 Issue: 5 in October-2021

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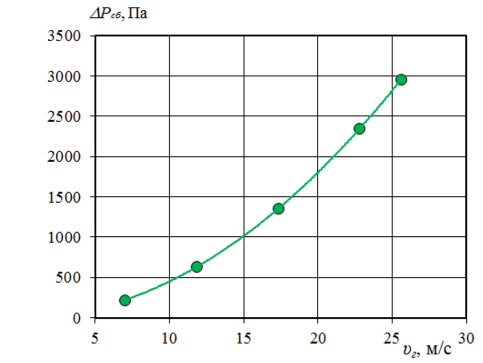
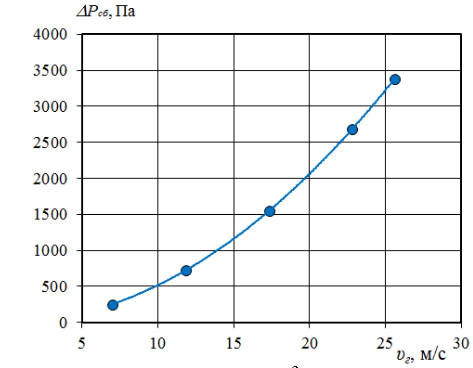
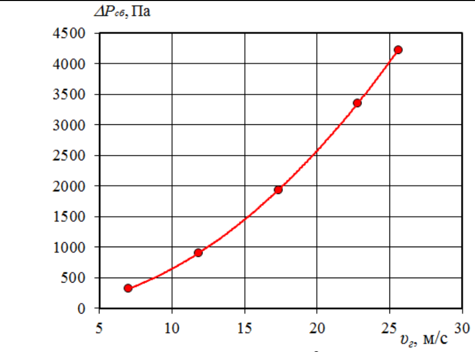



$\xi_{um} = 4.6$ and $\rho_g = 1.29$ kg/m$^3$ – const. **Figure 2.**




$\xi_{um} = 6$ and $\rho_g = 1.29$ kg/m$^3$ – const. Figure 3.




$\xi_{um} = 7.4$ and $\rho_g = 1.29$ kg/m$^3$ – const. **Figure 4.**

**Figures 2; 3 and 4. Device hydraulic resistance$\Delta P_{sb}$ gas velocity of $\upsilon_g$ dependence on**

In Figures 2, 3 and 4,the following empirical formulas were obtained using the least squares method for the graphical relationships shown [13,14,15,16].

*When* $\xi_{um} = 4.6$ and $\rho_g = 1.29$ kg / m$^3$ – const,

$y = 4,515x2 - 0.0004x - 0.0391R^2 = 0.9879$ (1)

*When* $\xi_{um} = 6$ and $\rho_g = 1.29$ kg / m$^3$ – const,

$y = 5,1598x2 + 0.0023x - 0.0056R^2 = 0.9989$ (2)

*When* $\xi_{um} = 7.4$ and $\rho_g = 1.29$ kg / m$^3$ – const,

$y = 7,2597x2 + 0.0056x - 0.0079R^2 = 0.9914$ (3)

In experimental studies to determine the treatment efficiency of the device, the amount of secondary gas in 1 m3 of hydrogen fluoride gas selected for the sample was 2459.1 mg / m$^3$ [11,12]. The device was installed in the secondary hydrogen-fluoride gas network coming out of the mixing reactors in the technological line of the superphosphate shop of JSC "Ferganaazot" (Figure 5).

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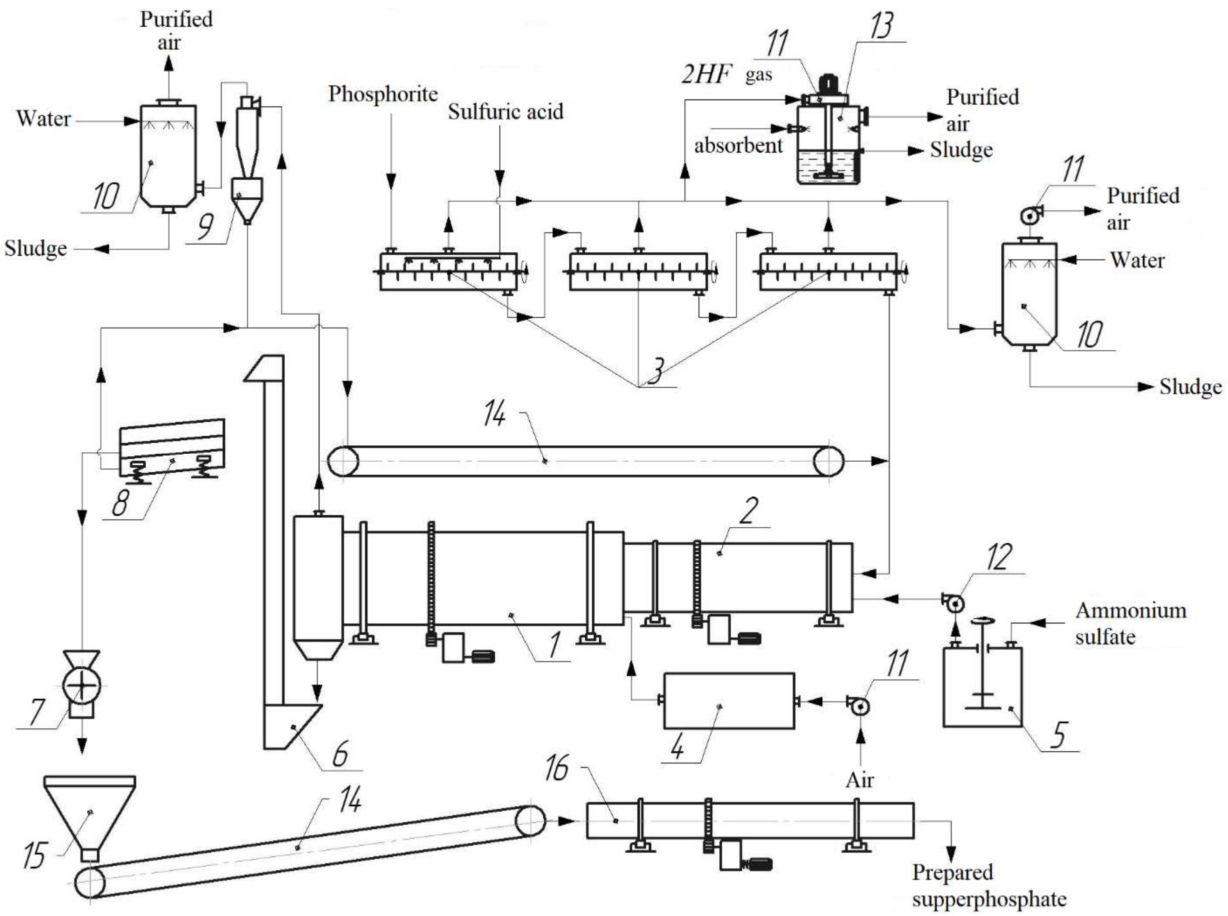


1-drum dryer; 2-drum granulator; 3-mixing horizontal reactor; 4-colorifier; 5-mixing vertical reactor; 6-bucket elevator; 7-hammer crusher; 8-gallon; 9-cyclone NIOGAS; 10-hollow scrubbers; 11-fan; 12-centrifugal type pump; 13-scrubber; 14-belt conveyor; 15-supply bunker; 16-drum refrigerator.

**Figure 5. Technological line for the production of superphosphate mineral fertilizers**

**Step 1:**

Experiments on the selected absorbents were performed depending on the velocity of the gas entering the device. The duration of each experiment was 30 minutes. Table 1 shows the laboratory analysis to determine the neutrality of the gas absorbed in the absorbent liquid medium.

**Table 1 Neutrality of gas absorbed in an absorbent liquid medium** results obtained on

| **When there is a 10% solution** | | | |
|---|---|---|---|
| $y$, m / s | Calcium technical white soda | Calcium carbonate soda | Technical shampoo |
| 7 | 6.5 | 6.14 | 5.8 |
| 11.83 | 6.1 | 5.9 | 5.61 |
| 17.32 | 5.85 | 5.67 | 5.12 |
| 22.8 | 5.34 | 5.1 | 4.83 |
| 25.6 | 5.1 | 4.79 | 4.42 |
| **When there is a 20% solution** | | | |
| 7 | 7.9 | 7.1 | 6.8 |
| 11.83 | 7.4 | 6.4 | 6.1 |
| 17.32 | 7.15 | 6.2 | 5.8 |
| 22.8 | 6.8 | 6.1 | 5.4 |
| 25.6 | 6.3 | 6.0 | 5.0 |
| **When there is a 30% solution** | | | |
| 7 | 9.9 | 8.7 | 8.1 |

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| | | | |
|---|---|---|---|
| 11.83 | 9.48 | 8.45 | 7.6 |
| 17.32 | 8.73 | 8.1 | 7.19 |
| 22.8 | 8.4 | 7.78 | 6.84 |
| 25.6 | 8.12 | 7.4 | 6.5 |

When the acid neutrality of the wastewater generated according to the technological requirement is higher than 7 Ph, the wastewater is considered alkaline and can be reused in industry. In the scrubber currently used in the production process, this condition is 3.5 ÷ 5.0 Ph. It can be seen from Table 1 that the purification of hydrogen fluoride gas into an absorbent liquid added as a solution of 10.20.30% to the water content and the increase in the neutrality of the resulting wastewater depend on the gas velocity supplied to the device.

**Step 2:**

The following results were obtained in experiments to determine the effective absorption of hydrogen fluoride gas in the absorbent liquid and to determine the cleaning efficiency of the device. Experimental studies used the experimental method of CT Simrau [1,4].

**Water in an absorbent added to the composition as a 10% solution.**

1. Calcium technical white soda - gas velocity in the range of 7 ÷ 25.6 m / s, absorption of toxic gas into the liquid up to 87.4 ÷ 92.6%.

2. Calcium carbonate soda - gas absorption of toxic gas into the liquid in the range of 7 ÷ 25.6 m / s to 81.8 ÷ 86.5%.

2. Technical shampoo - gas velocity in the range of 7 ÷ 25.6 m / s, absorption of toxic gas into the liquid up to 78.9 ÷ 84.7%.

**Water in an absorbent added to the composition as a 20% solution.**

1. Calcium technical white soda - gas absorption of liquid gas in the range of 7 ÷ 25.6 m / s to 93.4 ÷ 98.9%.

2. Calcium carbonate soda - gas absorption of toxic gas into the liquid at a velocity of 7 ÷ 25.6 m / s up to 84.7 ÷ 92.7%.

2. Technical shampoo - gas velocity in the range of 7 ÷ 25.6 m / s, absorption of toxic gas into the liquid up to 81 ÷ 88.5%.

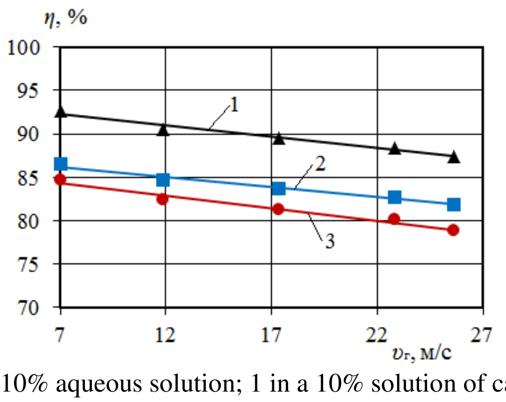
**Water in an absorbent added to the composition as a 30% solution.**

1. Calcium technical white soda - gas velocity in the range of 7 ÷ 25.6 m / s, absorption of toxic gas into the liquid up to 96.1 ÷ 99.4%.

2. Calcium carbonate soda - gas absorption of toxic gas into the liquid at a velocity of 7 ÷ 25.6 m / s up to 94 ÷ 97.3%.

2. Technical shampoo - gas velocity in the range of 7 ÷ 25.6 m / s, absorption of toxic gas into the liquid up to 90.4 ÷ 95.6%.

Based on the results of the experiments, a graph of the dependence of the cleaning efficiency of the device on the velocity of the gas supplied to the device was constructed. Experimental results 6; Shown in Figures 7 and 8.




1-calcium technical white soda in 10% aqueous solution; 1 in a 10% solution of calcium carbonate soda in water; 1 technical shampoo in 10% solution in water;

**Figure 6. Cleaning efficiency $\eta$ to the gas velocity $\upsilon_g$ dependence**

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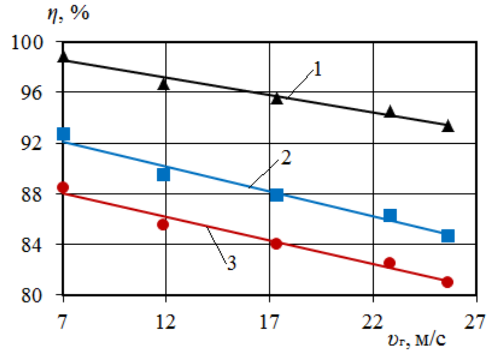
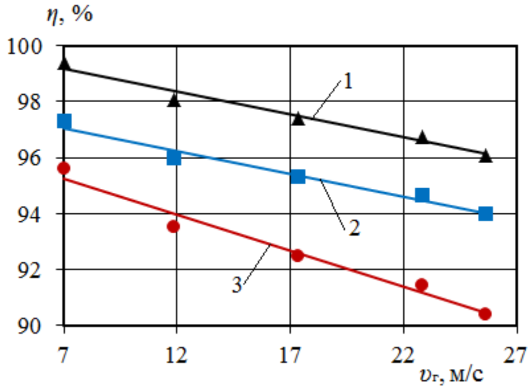



1-calcium in a 20% aqueous solution of technical white soda; 1 in a 20% solution of calcium carbonate soda in water; 1 technical shampoo in 20% solution in water;

**Figure 7. Cleaning efficiency$\eta$ to the gas velocity $\upsilon_g$dependence**




1-calcium technical white soda in a 30% solution in water; 1 in a 30% solution of calcium carbonate soda in water; 1 technical shampoo in a 30% solution in water;

**Figure 8. Cleaning efficiency$\eta$ to the gas velocity $\upsilon_g$ dependence**

6; 7 and 8The following empirical formulas were obtained using the least squares method for the graphical dependences shown in Figs [13,14,15,16]:

**Water in an absorbent added to the composition as a 10% solution.**

$y = 94{,}122e^{-0.003x}$ $R^2 = 0.9741$ (4)

$y = 87{,}873e^{-0.003x}$ $R^2 = 0.974$ (5)

$y = 86{,}417e^{-0.004x}$ $R^2 = 0.9744$ (6)

**Water in an absorbent added to the composition as a 20% solution.**

$y = 100.51e^{-0.003x}$ $R^2 = 0.9741$ (7)

$y = 95.11e^{-0.004x}$ $R^2 = 0.9749$ (8)

$y = 90{,}756e^{-0.004x}$ $R^2 = 0.9749$ (9)

**Water in an absorbent added to the composition as a 30% solution.**

$y = 100.35e^{-0.002x}$ $R^2 = 0.9734$ (10)

$y = 98{,}246e^{-0.002x}$ $R^2 = 0.9734$ (11)

$y = 97{,}119e^{-0.003x}$ $R^2 = 0.974$ (12)

Experimental results obtained when using the device to clean hydrogen fluoride gas and phosphoride dust in the air in the mixing reactors during the production of supperphosphate showed that the cleaning efficiency is 5.7% higher than

ISSN 2792-4025 (online), Published under Volume: 1 Issue: 5 in October-2021

the existing wet scrubber and the wastewater generated during the cleaning process is neutral. (Ph) increased from 5.4 to 9.9.

**Conclusion:**

Experimental studies show that:

- changes in the coefficient of resistance depending on different values of the injector diameter of the device lead to an increase in hydraulic resistance and an improvement in cleaning efficiency;
- The intermediate increase in cleaning efficiency at the minimum and maximum values of liquid consumption was found to be 6.7%.

In the process of purification of hydrogen fluoride gas, the flow rate was 17.32 m / s, a 30% solution of calcium technical white soda in water and a purification efficiency of 97.42% were found to be the optimal parameters for the device.

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ISSN 2792-4025 (online), Published under Volume: 1 Issue: 5 in October-2021