Investigating the Functional Performance of Plantago Ovate Plant as a Drug Carrier in a Targeted Drug Delivery System

Vahid Hosseini[1]; Seyed Masoud Ghoreishi Mokri[2]; Dalia hafezghoran[3]; Bahareh Karimi[4]; Anastasia Aleksandrovna Anashkina[5]; Anna Borisovna Yazykova[6]
[1]Dentistry Student at Privolzhsky Research Medical University, Nizhny Novgorod, Russia
[2]Department of Medicine at Privolzhsky Research Medical University, Nizhny Novgorod, Russia
[3]General Medicine Department of Privolzhsky Research Medical University
[4]Dentistry Department of Privolzhsky Research Medical University
[5]PhD, the Head of the Biochemistry Department of Privolzhsky Research Medical University
[6]Phd , Senior Professor of Biochemistry Department of Privolzhsky Research Medical University

Abstract:- The drug delivery systems that were used in the past were done without any control over the time, place and speed of drug release, and this caused the amount of drug released in the blood to fluctuate, that is, the concentration of the drug in the blood could vary from The therapeutic range will be exceeded and its side effects will also increase. Therefore, with targeted medicine, it is possible to control the place of drug release, its speed and time, and minimize the side effects caused by the drug. In this regard, in this research, the natural hydrogel extracted from the Plantago ovate plant as one of the drug carriers in the body environment in order to increase the efficiency and reduce the degradation of the drug, prevent the side effects caused by the use of the drug and increase the access to the drug and improve Its effect was investigated at the lesion site. In this context, after extracting the natural hydrogel from Plantago ovate plant, the swelling rate of Plantago ovate gel powder was investigated at different pH, the FT-IR spectrum obtained from Plantago ovate hydrogel and the swelling rate of Plantago ovate mucilage at different pH were investigated. Therefore, the obtained results indicate that natural polysaccharides can be used as a natural drug carrier in drug delivery systems due to their high biocompatibility in the body environment, non-toxicity and cheapness.

***Keywords**:- Targeted Drug Delivery - Plantago Ovate Plant - Natural Hydrogel - Polymer Nanoparticles.*

I. INTRODUCTION

Nanoparticle-based drug delivery systems have received much attention and use in recent years. The pattern of using drug carriers in the body environment in order to increase the efficiency and reduce the degradation of the drug, prevent the side effects caused by the use of the drug and increase the access to the drug and improve its effect in the lesion site was investigated and used, and many pharmaceutical researches and clinical studies were conducted on this issue [1].

In a general definition, it can be said that particles whose size is in the range of (10- 100) nanometers are called nanoparticles. Nanoparticles, due to their very small size and high surface-to-volume ratio, can be used to attach multiple ligands to the surface due to their tendency to create multiple covalent bonds. Other characteristics of nanoparticles include chemical and biological stability, the possibility of binding to both hydrophilic and hydrophobic drugs, and the ability to be prescribed by different routes such as oral, inhalation and injection [2]. These nanoparticles have the ability to carry the drug in a dissolved, trapped, encapsulated or attached to the nanoparticle matrix.[3]

Encapsulation is a technique that uses that substance or a combination of substances to be covered by another system. The coated material is called active material or core material and the coating material is called carrier or encapsulant. In recent years, this technique has made a lot of progress and growth in scientific and industrial societies. This method can be used to improve the efficiency, increase the stability, increase the compatibility of the active substance, increase safety, and also use it as a carrier in the targeted delivery of substances [4]. In this regard, in this research, the Plantago ovate plant and the natural hydrogel extracted from it have been investigated.

II. CHARACTERISTICS OF THE PLANTAGO OVATE PLANT AND THE NATURAL HYDROGEL EXTRACTED FROM IT

Plantago ovata with its scientific name belongs to the family of plantain plants, this plant is native to parts of Asia, Mediterranean and North Africa and is mainly found in Iran, India and Pakistan. Plantago ovate seed is almost boat-shaped and has a brownish color. Plantago ovate bran is obtained by grinding its seeds [5-6].

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1087

Fig 1: Plantago Ovate Seed

Among the natural polysaccharides that have recently been considered and studied in the field of hydrogel and drug delivery, the hydrogel extracted from Plantago ovate bran has been one of the most promising, a practical and light polymer that is easily available at low cost [7].

Plantago ovate bran is rich in a type of soluble fiber or mucilage, which has a long history of improving colon function and reducing the risk of colon cancer. This plant is used as a useful and effective food supplement in the treatment of digestive disorders. Also, weight loss and blood cholesterol level reduction are also reported among other medicinal properties of this plant [8].

In 1998, the US Food and Drug Administration (FDA) confirmed the healthiness of Plantago ovate bran and suggested that consuming 3-12 grams of soluble fiber obtained from Plantago ovate bran as a supplement in a low-fat diet can reduce the risk of heart disease [6]. About 55-60% of the bran of Plantago ovate is made up of mucilage. This mucilage is a fibrous and white part that has the ability to absorb water and form a colorless and transparent gel [9].

Fig 2: Plantago Ovate Bran

According to the studies done on Plantago ovate seed, it has been determined that Plantago ovate bran is covered with neutral arabinoxylan, which contains 6.22% arabinose, 74.6% xylose and some other sugar elements [7].

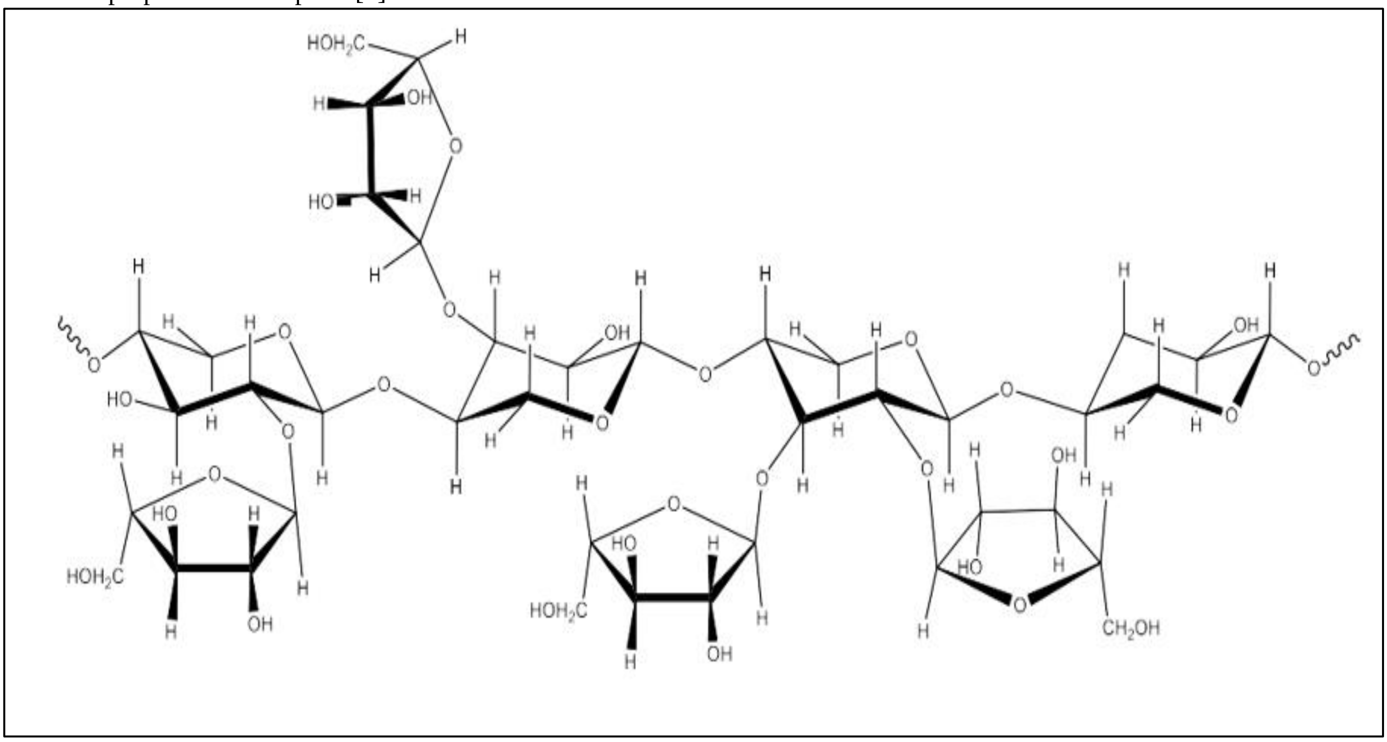

Fig 3: Structure of Arabinoxylan Molecule [7].

Cross connections between arabinoxylan chains are covalent and ferulic acid bridges, and are partially responsible for the insolubility of arabinoxylan [10].

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1087

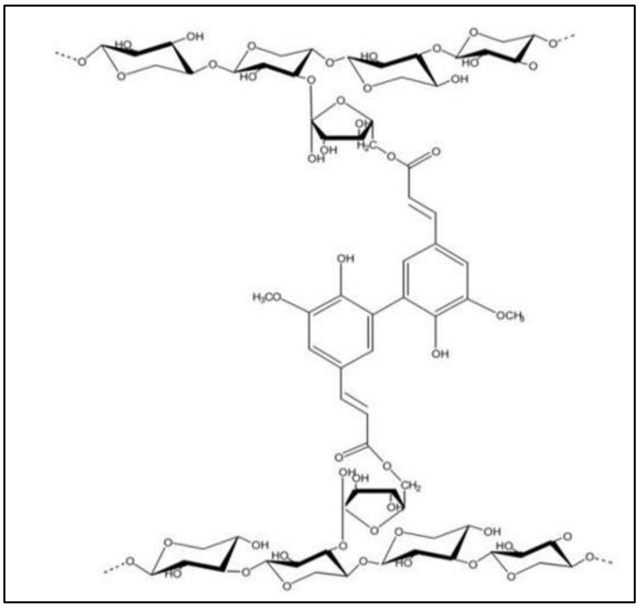

Fig 4: Transverse Bridges in Arabinoxylan Chains

III. NANOPARTICLES OF LIPID AND POLYMER ORIGIN

Nanoparticles with lipid origin include liposomes, microemulsions and solid lipid nanoparticles, and the main base of their producing materials is fat [11] and nanoparticles with polymer origin are nanoparticles that are widely used in drug delivery. One of the characteristics of the polymers used in this field is their biocompatibility and non-toxicity. The advantages that this category of nanoparticles have over others is the ability to synthesize them in large quantities and also their stability. In this research, the hydrogel extracted from the Plantago ovate plant has been discussed.

➢ *Hydrogels*

For the first time in the early 1960s, Lim and Wichterle began their biological studies on a hydrophobic gel. After that, until today, a lot of efforts and studies have been devoted to the development and expansion of the capabilities of hydrogels [12]. In general, hydrogels can be called polymer networks (or structure) with a three- dimensional configuration that have transverse connections and are able to absorb large amounts of water or biological fluids [12-13].

The ability of hydrogel to absorb water is due to the presence of hydrophilic groups such as SO_3H, OH, CONH and $CONH_2$ in the structure of the constituent monomers, depending on the contribution of these groups and the nature of the aqueous environment and the composition of the polymer, the hydrogel can have different degrees of hydration which sometimes reaches 90% of the weight of the gel. On the other hand, there are also hydrophobic polymer networks, such as polylactic acid (PLA) or poly lactic-co-glycolic acid (PLGA), which have a low water absorption capacity (about 5-10%). The content of water that can be absorbed by the hydrogel determines its unique chemical and physical properties. The fully swollen hydrogel has physical properties in common with living tissues, including its soft and elastic texture and interfacial tension with water and other biological body fluids. Due to their high water absorption power, hydrogels swell instead of dissolving in water and therefore acquire elastic properties, which minimizes the irritation of the tissues around the hydrogel after implantation. Low interfacial tension, between the hydrogel surface and body fluids, reduces protein absorption and cell adhesion, which reduces the body's negative reaction. In addition to the mentioned advantages, the pores in the hydrogel create the ability to contain the drug and therefore can be used as a drug delivery system. In this context, hydrogels can be used in the form of nanoparticles, microparticles, pieces and films [12-14].

The reason why the gel does not dissolve in water is the presence of transverse connections between the polymer chains that make up the hydrogel, these stable connections may be in the form of covalent bonds or in the form of non-covalent physical bonds such as ionic bonds, hydrogen bonds, hydrophobic bonds and physical entanglements [15].

IV. EXTRACTION OF PLANTAGO OVATE HYDROGEL

In order to extract Plantago ovate hydrocolloid for use in the production of magnetic nanocapsules, 50 grams of Plantago ovate seeds were ground for 2 minutes by a laboratory grinding machine, and then the bran was separated from the kernel using a laboratory sieve (mesh 20). After grinding and sieving, the obtained amount was about one-third of the initial weight of Plantago ovate seeds (17 grams).

In order to obtain the hydrogel of Plantago ovate plant, 30 times the weight of bran (500 ml) of distilled water was added and allowed to remain at room temperature for 24 hours. After that, 96% ethanol was added to the mixture in the amount of 3 times the volume of the obtained gel, so that the gel remained suspended in the solution. The resulting sediment was washed 3 times with ethanol, and then it was ground with a Chinese mortar in order to perform other tests [15]. The obtained gel powder was identified by FT-IR spectroscopy. In addition, the swelling rate of this hydrogel was investigated at different pH (4.2, 7.4, 9.0).

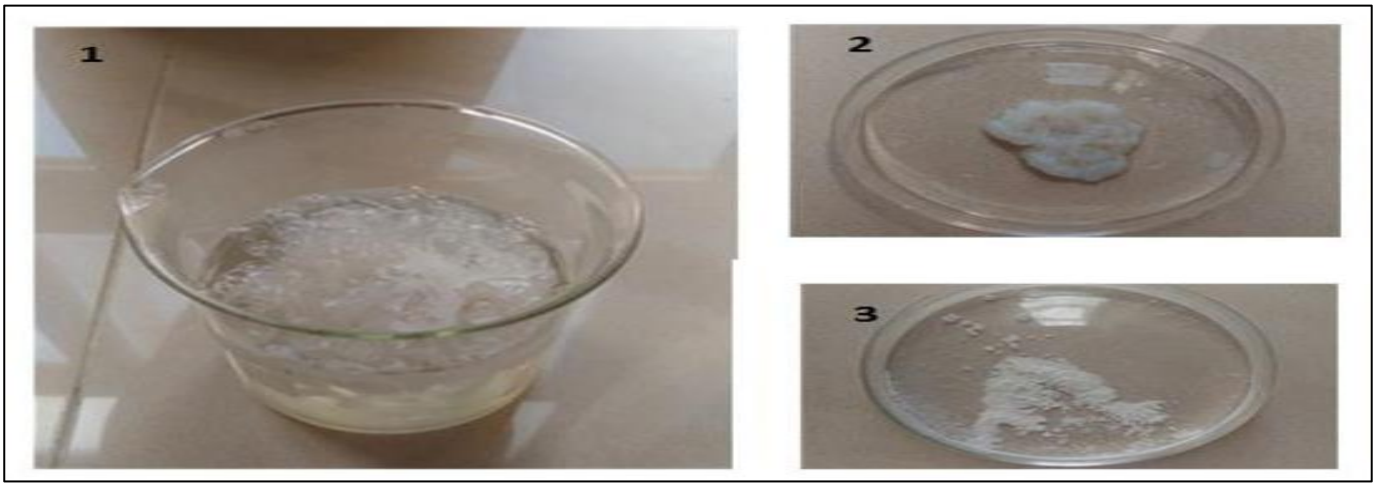

Fig 5: Steps of Extracting Gel Powder in the Laboratory

A. Investigating the Swelling of Plantago Ovate Gel Powder at Different pH

After preparing three acidic, basic and neutral solutions (Ph = 2.4, 4.7, 9), the resulting gel powder was added in equal proportion to all three solutions and after one hour and complete swelling, the excess solvent was removed by filter paper.

B. Identification of the Hydrogel Extracted from Plantago Ovate

Mucilage or fibrous and white part that can be extracted from the bran of Plantago ovate and is the main factor of water absorption in this plant. Its main ingredient is neutral arabinoxylan.

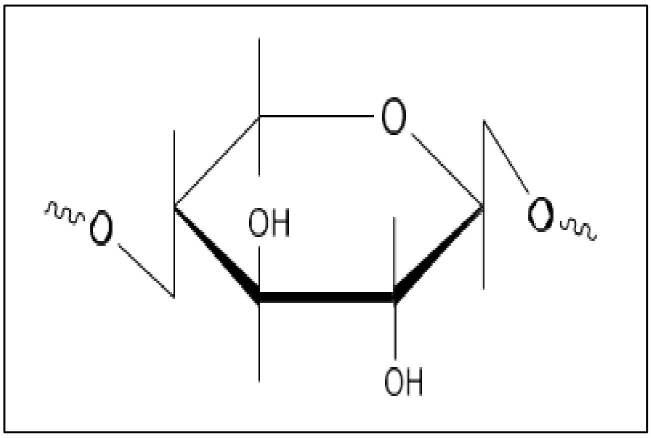

Fig 6: The Structure of the Main Component Found in Plantago Ovate Mucilage [16].

C. Investigation of FT-IR Spectrum Obtained from Plantago Ovate Hydrogel

The band related to stretching vibrations of C—O—C bonds can be seen in the range of 1040 Cm^{-1}. The band seen around 2900 $Cm^{-1}$is also related to the CH alkyl stretching vibrations in the compound. Also, the broad band appearing at 3400 $Cm^{-1}$is related to the stretching vibration of O—H bonds in the compound [17].

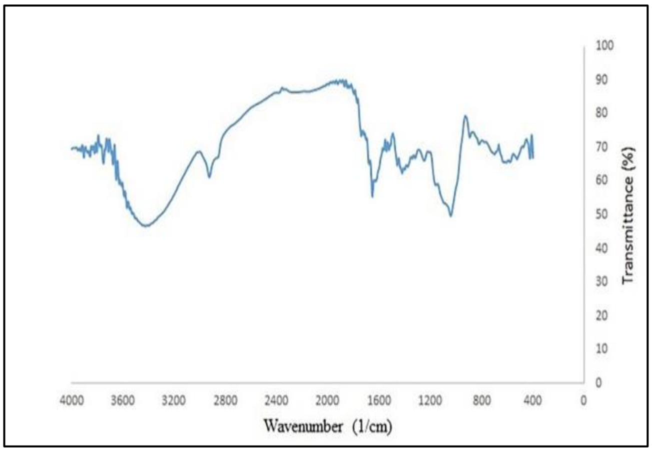

Diagram 1: FT-IR spectrum obtained from Plantago ovate hydrogel

Investigating the amount of swelling of Plantago ovate mucilage at different pH The results of the investigation of the swelling of the Plantago ovate in three acidic, neutral and basic environments are shown in diagram [2]. As can be seen, the highest amount of swelling is related to the neutral solvent (pH=4.7). This feature can be considered as one of the merits of this natural hydrogel for targeted pharmaceutical systems.

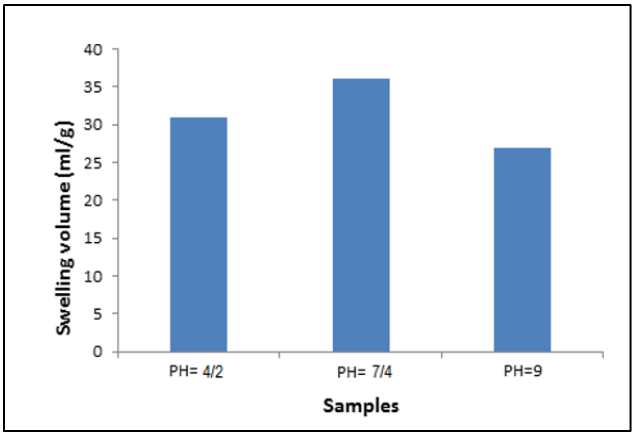

Diagram 2: Investigation of the swelling rate of Plantago ovate powder at different pH

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1087

V. CONCLUSION

Natural polysaccharides are suitable options for use as drug carriers due to their advantages such as their high biocompatibility in the body environment, their non- toxicity and their cheapness. In addition to its benefits in solving problems of the digestive system and reducing blood cholesterol, the mucilage extracted from the shell of Plantago ovate can be used as a natural drug carrier in drug delivery systems due to its cross-links and reticulated.

REFERENCES

[1]. Yun YH, Lee BK, Park K. Controlled drug delivery: historical perspective for the next generation. Journal of Controlled Release. 2015;219:2-7.

[2]. Masserini M. Nanoparticles for brain drug delivery. ISRN biochemistry. 2013;2013.

[3]. Hamidi M, Azadi A, Rafiei P. Hydrogel nanoparticles in drug delivery. Advanced drug delivery reviews. 2008;60(15):1638-49.

[4]. Tan Tai LH. Formulating detergents and personal care products. A complete guide to product development. AOCS Press; 2000.

[5]. McCredie R, Whistler RL. Quince seed, psyllium seed and flaxseed gums. Industrial Gums, 2nd Ed, RL Whistler and JN BeMiller (eds) Academic. 1965:433-57.

[6]. Juturu V, Gormley J. Bioactive Nutrients and Cardiovascular Disease. Bioactive Food as Dietary Interventions for Cardiovascular Disease: Elsevier; 2013. p. 73-88.

[7]. Thakur VK, Thakur MK. Recent trends in hydrogels based on psyllium polysaccharide: a review. Journal of Cleaner Production. 2014;82:1-15.

[8]. Marcus JB. “Shake It Up! Modifying Traditional Foods and Recipes to Lower Sodium” Jacqueline B. Marcus, MS, RD, LD, CNS, FADA Food and Nutrition Consultant/Owner Jacqueline B. Marcus and Associates Highland Park, Illinois USA. 2013.

[9]. Fischer MH, Yu N, Gray GR, Ralph J, Anderson L, Marlett JA. The gel-forming polysaccharide of psyllium husk (Plantago ovata Forsk). Carbohydrate research. 2004;339(11):2009-17.

[10]. Izydorczyk M. Arabinoxylans. Handbook of Hydrocolloids (Second Edition): Elsevier; 2009. p. 653-92.

[11]. Ekambaram P, Sathali AAH, Priyanka K. Solid lipid nanoparticles: a review. Sci Rev Chem Commun. 2012;2(1):80-102.

[12]. Hamidi M, Azadi A, Rafiei P. Hydrogel nanoparticles in drug delivery. Advanced drug delivery reviews. 2008;60(15):1638-49.

[13]. Bhattarai N, Gunn J, Zhang M. Chitosan-based hydrogels for controlled, localized drug delivery. Advanced drug delivery reviews. 2010;62(1):83-99.

[14]. Kreuter J, Ramge P, Petrov V, Hamm S, Gelperina SE, Engelhardt B, et al. Direct evidence that polysorbate-80-coated poly (butylcyanoacrylate) nanoparticles deliver drugs to the CNS via specific mechanisms requiring prior binding of drug to the nanoparticles. Pharmaceutical research. 2003;20(3):409-16.

[15]. Wichterle O, Lim D. Hydrophilic gels for biological use. Nature. 1960;185(4706):117.

[16]. Tripathi R, Mishra B. Preparation and evaluation of composite microspheres of polyacrylamide-grafted polysaccharides. Journal of Applied Polymer Science. 2013;130(4):2912-22.

[17]. Singh B, Bala R. Design of radiation crosslinked psyllium and binary monomers-based hydrogels for use in colon drug delivery. International Journal of Polymeric Materials. 2013;62(2):68-75.

[18]. Mokri SM, Valadbeygi N, Stelnikova IG. Using Convolutional Neural Network to Design and Predict the Forces and Kinematic Performance and External Rotation Moment of the Hip Joint in the Pelvis. International Journal of Innovative Science and Research Technology (IJISRT) IJISRT24FEB1059. 2024:878-83.

[19]. Valadbeygi N. A Parametric Study to Predict Wind Energy Potential from Neural Network.

[20]. Mokri SM, Valadbeygi N, Grigoryeva V. Diagnosis of Glioma, Menigioma and Pituitary brain tumor using MRI images recognition by Deep learning in Python. EAI Endorsed Transactions on Intelligent Systems and Machine Learning Applications. 2024 Apr 15;1.

[21]. Valadbeygi N. Wet Cooling Tower Heat Transfer and Function Prediction using MLP Neural Network.

[22]. Mokri SM, Valadbeygi N, Balyasimovich KM. Predicting the Performance and Adaptation of Artificial Elbow Due to Effective Forces using Deep Learning".

[23]. Mokri SM, Valadbeygi N, Mohammed K. Physiological study of joint loaded force in the artificial knee with the neural approach.

[24]. Valadbeygi N, Shahrjerdi A. Prediction of Heating Energy Consumption in Houses via Deep Learning Neural Network. Analytical and Numerical Methods in Mechanical Design. 2022 Dec 1;1(2):11-6.

[25]. Hosseini V, Mokri SM, Viktorovna KA. Targeted Drug Delivery through the Synthesis of Magnetite Nanoparticle by Co-Precipitation Method and Creating a Silica Coating on it.