

A Review on Matrix Tablet for Sustained Drug Release

Suraj Yadav^[1], Mohd Abid Khan^[2], Dheeraj Kumar Yadav^[3]

Rajasthan Pharmacy College, (Dept. of Pharmaceutics) Bhankrota, Jaipur, (Rajasthan), India^[1,2]
Smt. Vidyawati college of pharmacy, (Dept. of Pharmaceutical Chemistry) Jhansi, (U.P.), India^[3]

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Abstract

The oral route remains the most preferred route for drug administration due to its ease and patient acceptance, but conventional dosage forms require frequent dosing which leads to fluctuations in plasma drug levels. To overcome this problem, sustained release matrix tablets have been developed as an effective alternative. In this system, the drug is uniformly dispersed within a polymer matrix that controls its release over an extended period of time. Various types of polymers such as hydrophilic polymers like hydroxypropyl methylcellulose, hydrophobic polymers like ethyl cellulose and natural polymers like xanthan gum and guar gum are used as release retardants. The release of drug from matrix tablet takes place mainly by diffusion through gel layer, swelling of polymer and slow erosion of matrix. Recently, the field has witnessed remarkable innovations including blending of natural and synthetic polymers, introduction of gastro-retentive and mucoadhesive matrix systems, application of 3D printing for personalized tablets and development of pH sensitive smart matrices. These advancements have improved the efficiency and safety of matrix systems. Looking ahead, the combination of biodegradable polymers, nanocarriers and artificial intelligence based design is expected to make matrix tablets more targeted, sustainable and patient friendly. This review summarizes the current status, release mechanisms, recent developments and future scope of matrix tablets for sustained drug delivery.

Keyword- Matrix tablet, Sustained drug release, Controlled release, Oral drug delivery, Hydrophilic polymer, HPMC, Drug release kinetic, Dissolution testing

I. Introduction

Oral sustained-release formulations have received significant focus due to their potential to improve therapeutic effectiveness and boost patient adherence. Expandable drug delivery systems are a notable advancement, providing prolonged gastric

retention and regulated drug release by employing size-based retention methods.(Chandra et al, 2026)

These terms include delayed release, repeated action, prolonged release, sustained release, extended-release, and controlled release, all of which illustrate altered release characteristics.(kumar et al, 2024)

In contrast to traditional dosage forms that quickly release their active pharmaceutical ingredients (APIs), sustained release systems are intended to deliver the medication gradually over a longer duration, thus keeping a steady plasma drug concentration within the therapeutic range. (Dagale et al, 2025)

Sustained release matrix tablets constitute a notable breakthrough in pharmaceutical drug delivery systems, created to boost therapeutic effectiveness while reducing adverse effects. These dosage forms are designed to release active ingredients at a controlled rate, enabling longer-lasting therapeutic effects and better patient compliance. Through the use of various polymers, including hydrophilic and hydrophobic materials, the matrix structure efficiently controls the diffusion of the drug, maintaining a steady concentration in the bloodstream over prolonged periods. The formulation of these tablets usually involves methods such as wet granulation or direct compression, which incorporate the drug within a matrix of excipients. This design not only extends the release of the drug but also lowers the frequency of dosing, which is especially advantageous for chronic conditions that require consistent medication levels.(Nagendra et al. ; Dikshit et al.,2023) Tablets are the primary frequently and extensively utilized dosage form. This kind of medication distribution system is referred to as traditional medication administration approach and is recognized for delivering an instant relief of medication(Dash et al. , 2013)Oral drug delivery continues to be the most broadly accepted and favored route of administration, owing to its convenience, patient compliance, and cost-effectiveness, as well as the ease with which it can

be manufactured on a large scale. Nevertheless, conventional immediate-release dosage forms frequently necessitate frequent dosing in order to sustain therapeutic plasma concentrations, which results in poor patient adherence and a heightened risk of dose-related side effects. To address these limitations, sustained release (SR) drug delivery systems have been developed extensively, with the aim of keeping drug concentrations within the therapeutic window for extended periods while reducing dosing frequency and fluctuations in plasma levels fluctuations.(Shinde et al. , 2026)

1.1 Sustained Drug Delivery System

The earliest developments in sustained drug delivery dosage forms likely date back to 1938 patent by Israel Lipowski. This project included coated pellets for extended drug release and was likely precursor to the advancement of the coated particle method for prolonged drug delivery that was

introduced in the early 1950s. Ideally, a medication should reach the action site (receptor) quickly at the ideal concentration. stay for the specified duration, be barred from other locations, and be quickly taken off the site when requested, i.e. the primary aim of the treatment is to attain a consistent blood concentration that is both effective therapeutically and non-harmful. for a prolonged duration.(Dixit et al. ,2013)

It encompasses all types of drug delivery systems. accomplishes the delivery of medication over a prolonged duration that is independent of time. Water-attracting polymer matrix is commonly utilized. for creating a Sustained release form. The function of an optimal drug delivery system is to administer appropriate dosage of medication consistently time frame & at correct location of effect to sustain therapeutic levels of medication in blood stream (Ratnaparkhi et al. , 2013)

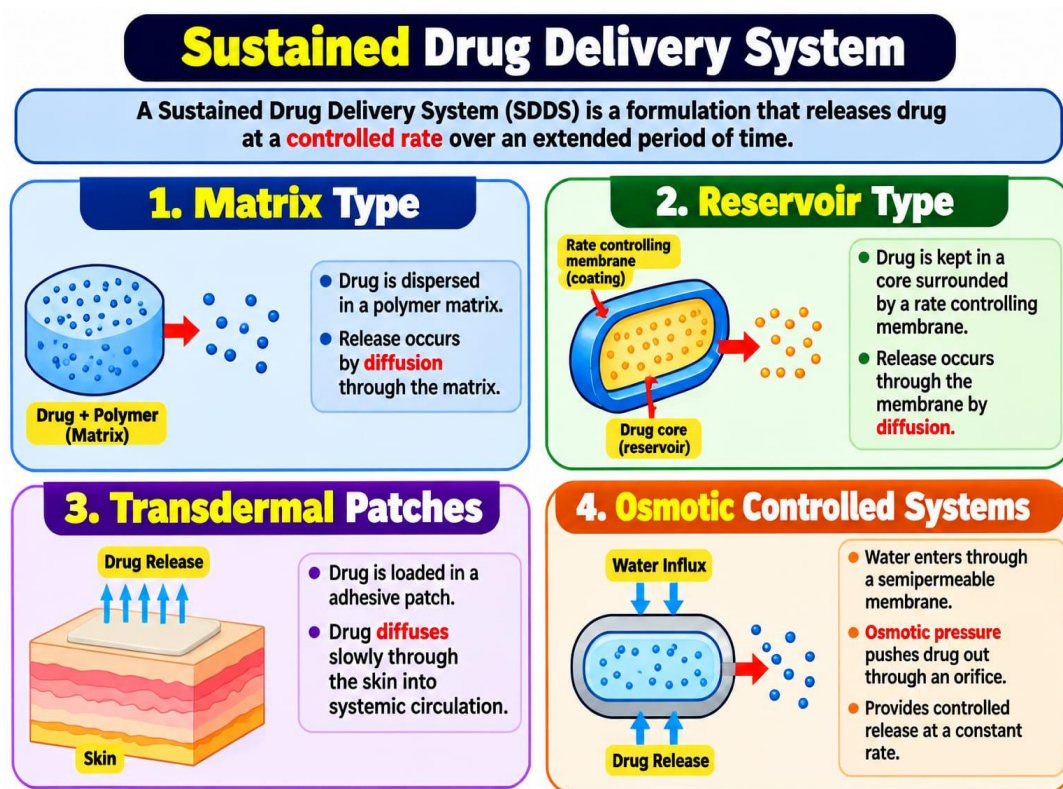


Fig. No. 1 Sustained Drug Delivery System

Matrix system

A matrix system includes both active and inactive components that are uniformly distributed and combined in the dosage form. It is

unquestionably the most frequently utilized oral extended-release technology and the appeal of the matrix systems may be ascribed to various reasons. The liberation from Matrix type formulations are

regulated by Fick's first principle of diffusion. The medication is spread within the polymer matrix either by combining a therapeutic amount of smoothly milled substance fragments with a fluid polymer or a very thick base polymer, succeeded by cross-linking of the polymer strands, blending medication and polymer at a higher temperature. It may also be produced by dissolving the medication and the polymer in a shared solvent, succeeded by solvent evaporation at an increased temperature and/or in a vacuum.

$$Q/t^{1/2} = (2ACRD_p)^{1/2}$$

Where,

A is the starting drug dose in the polymer matrix.

CR represents the concentration of the drug within the reservoir in the system;

D_p represents the diffusivity of the drug molecules within the polymeric matrix.

The release of the drug is regulated by managing the administering dose, solubility of drug in polymer and its diffusivity within the polymer matrix and the porosity of the distribution unit. It seems you've provided a reference number but haven't included any text to paraphrase. (Rao et al., 2013)

The features outlined below differentiate it from other controlled release delivery systems.

- The chemical composition of the support
- The physical state of the drug
- The structure of the matrix
- The change in volume over time
- The model of release kinetics

The drug is contained in a swellable hydrophilic polymer, an insoluble matrix of hydrophobic substances, and plastic components to control the release of the drug with different solubility characteristics. (Shivani et al., 2026)

1.1.2 Types of Matrix Tablets

➤ Hydrophilic Matrices

Hydrophilic polymer matrix systems are commonly utilized in oral regulated drug administration due to their adaptability to achieve an optimal drug release pattern, affordability, and extensive regulatory approval. The development of the medications in gelatinous capsules or more commonly, in tablets, employing hydrophilic polymers characterized by elevated gelling abilities as base excipients is especially significant in the area of regulated release

A. **Non cellulose natural or semi synthetic polymers:**

Agar-Agar; Carob gum; Alginates; Treacle; Mannose and galactose polysaccharides, chitosan and Altered starches.

B. **Cellulose derivatives:**

Methylcellulose 400 and 4000cPs, Hydroxyethylcellulose, Hydroxypropylmethylcellulose (HPMC) 25, 100, 4000 and 15000 cPs; along with Sodium carboxymethylcellulose.

C. **Polymer of acrylic acid:**

Carbopol 934 Additional hydrophilic substances utilized for Components for the formulation of matrix tablets include Alginic acid and Gelatin and organic resins (Manish et al., 2012; Kumar et al., 2024)

➤ **Lipid Structures**

These matrices created by the lipid waxes and associated supplies. Release of drugs from these matrices takes place via both diffusion through pores and erosion. Release features are thus more responsive to the composition of digestive fluids rather than to completely insoluble polymer matrix. Carnauba wax is found in mixed with stearyl alcohol or stearic acid has been employed as a retardant base for various sustained release composition. (Manish et al., 2012)

➤ **Biodegradable Matrices:**

These are made up of polymers formed from monomers connected to each other via functional groups and possess unstable connections in the backbone. They are biologically broken down or worn away by enzymes produced by nearby living cells or through a non-enzymatic process into oligomers and monomers that are capable of being metabolized or eliminated. Instances include natural polymers like proteins and polysaccharides; altered biological polymers; man-made polymers like aliphatic poly (esters) and poly anhydrides (Sharma et al. 2015)

➤ **Mineral Frameworks**

These are made up of polymers that are derived from different varieties of seaweeds. Alginic acid serves as a prominent example of a water-attracting carbohydrate derived from types of brown seaweeds (Phaeophyceae) through the application of weak alkali. (Shah et al., 2015)

➤ **Matrices that can decompose naturally**

These are made up of the polymers that consisted of monomers connected to each other via functional groups and possess inconsistent connections in the backbone. They undergo biological degradation or erosion by enzymes produced by adjacent living cells or through a non-enzymatic mechanism into oligomers and monomers that can be broken down or eliminated. Instances include natural polymers like proteins and polysaccharides; altered natural polymers synthetic polymers like aliphatic poly(esters) (Rao et al. , 2013)

1. Release Mechanisms

Release kinetic analysis indicated that the optimized formulations mainly adhered to Higuchi and models of zero order. Higuchi kinetics suggest diffusion

regulation, while zero-order frameworks recommend continuous release regardless of focus. The n-values of Korsmeyer–Peppas values ranging from 0.5 to 1.0 denote unusual (non-Fickian) transport—implying a combination of diffusion and processes of erosion. These results indicate that the mechanism of drug release is controlled by an intricate interaction involving diffusion via the matrix and polymer decay or degradation. The dominance of irregular transportation underscores the significance of both physical and chemical elements influencing discharge rates. These controlled release profiles are beneficial for sustaining therapeutic medication concentrations for prolonged durations. (Kulkarni et al. , 2025)

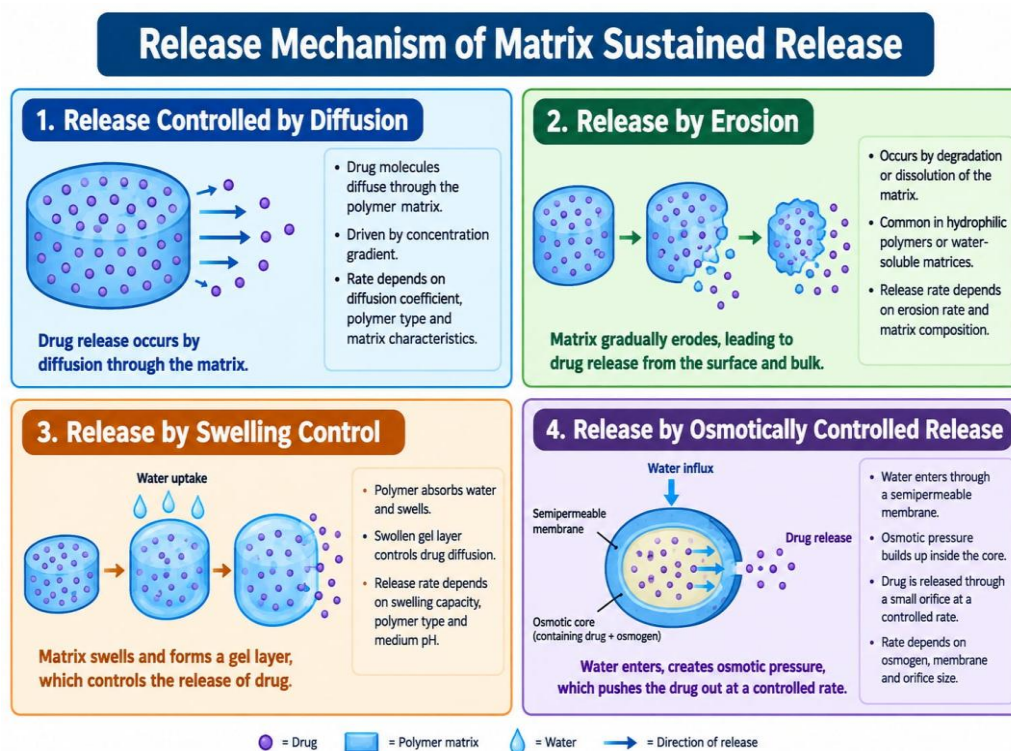


Fig. no. 2 Release mechanism of matrix sustained release

➤ Release Controlled by Diffusion

The medication moves through a polymer matrix or membrane, and this process is mainly regulated by Fick's law of diffusion. The polymer network, regardless of being hydrophilic or hydrophobic, influences the porosity and tortuosity of the diffusion route, thus impacting the release rate. Hydrophilic matrices usually expand and form aqueous pathways, while hydrophobic matrices

restrict fluid infiltration and hinder diffusion. The gradient of drug concentration serves as the motivating factor, facilitating ongoing diffusion for multiple hours. (Atul et al. ,2025)

➤ Release Controlled by Erosion

In systems based on erosion, the release of drugs happens as the polymeric framework slowly breaks down or deteriorates in the digestive system

surroundings. Erosion may be superficial—regulated or mass-regulated, based on creation. Decomposable polymers like polylactic acid glycolic acid enables consistent erosion, rendering them appropriate for prolonged shipment. The rate of erosion can be via the molecular weight of polymers, crystallinity, along with additives, guaranteeing extended-availability of drugs. Erodible polymers like poly anhydrides provide another intriguing material platform for zero order medication liberation. (Rao et al. 2013; Atul et al. ,2025)

➤ **Tablets With Osmotic Sustained Release**

Osmotic delivery systems are sophisticated controlled-release technologies. The release of the drug happens via osmotic pressure created inside the tablet.

Benefits

Anticipated launch pH-agnostic effectiveness
Minimal effects of food (Duddagi et al. , 2026)

➤ **Swelling-Controlled Release System**

Swelling-controlled release is an important mechanism in hydrophilic matrix tablets. In this type of system, the polymer used is hydrophilic in nature and has high affinity for water. When the tablet comes in contact with gastrointestinal fluids, the polymer starts absorbing water and swells to

form a thick gel layer around the tablet (Mamidala et al., 2009).

This gel layer acts as a barrier and controls the release of drug. Initially, the drug present on the surface dissolves quickly, but later the drug from inner core has to pass through this swollen gel network by diffusion. As time increases, the thickness of gel layer increases due to continuous water uptake, which further slows down the drug release (Kumar et al., 2019).

The rate of drug release in swelling-controlled system mainly depends on two processes: rate of water penetration into matrix and rate of polymer swelling. If swelling is fast, the gel layer forms rapidly and provides sustained release for longer time. Polymers like Hydroxypropyl Methylcellulose (HPMC), Sodium Carboxymethyl Cellulose and xanthan gum are widely used for this purpose because they show good swelling capacity (Dash et al., 2013).

In some cases, swelling is followed by erosion of the outer gel layer. This combination of swelling and erosion provides more uniform drug release and avoids dose dumping. Recent studies have shown that blending of natural gums with HPMC improves swelling index and gives better control over release profile (Mehta et al., 2021; Mohaniya et al., 2024).

Thus, swelling-controlled mechanism is considered as the most reliable and simple approach for designing sustained release matrix tablets.

2. **Polymers Used in Matrix Tablets**

TYPE	EXAMPLE
Biodegradable polymers	Polyacetic acid (PLA) Polyglycolic acid (PGA) Polyanhydrides
Non-biodegradable polymers	Cellulose acetate (CA) Polyethylene vinyl acetate (PVA) Polyether urethane (PEU)
Hydrogels	Poly-hydroxyethyl methacrylate (PHEMA) Cross-linked polyvinyl alcohol (PVA) Polyacrylamide(PA)
Mucoadhesive polymers	Polycarbophil Sodium Carboxymethylcellulose Tragacanth Methylcellulose
Soluble polymers	Polyvinyl alcohol (PVA) Polyethylene glycol (PEG)
Natural gums	Gum arabic Xanthan gum Karaya gum Guar gum

Cellulose Derivative	hydroxylpropylmethylcellulose(HPMC) 25,100,4000& 15000cps , hydroxyethylcellulose (HEC) , Sodiumcarboxymethyl cellulose and methylcellulose400&4000cps
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Table 1. Polymer used in matrix tablet (Kumar et al.,2019; Mehta et al., 2021)

IV. Formulation Methods

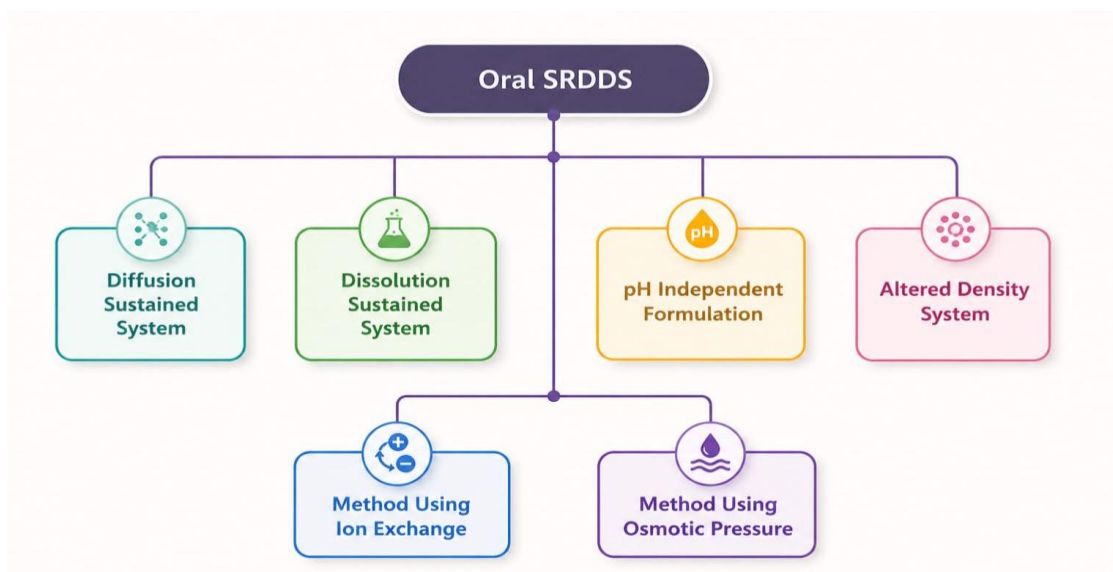


Fig. No. 3 Formulation method Of Oral SRDDS

4.1 Diffusion Sustained System

In these systems, the diffusion of the dissolved medication through a polymeric barrier serves as a rate-limiting factor. The rate of drug release is always non-zero order due to the increase in diffusional path length as time passes, the insoluble matrix is slowly diminished of medication. Spread of a drug molecule across a polymeric membrane serves as the foundation for these regulated drug delivery systems. Like the dissolution-controlled systems, the diffusion Devices that are controlled are produced either by encasing the medication particle within a polymer membrane or by distributing the medication within a polymeric matrix. In contrast to the dissolution-governed systems, the medication becomes accessible due to separation via the polymer. In the scenario of a reservoir type diffusion regulated apparatus, the velocity of medication discharge (dm/dt) can be computed using the subsequent formula : $dm/dt = ADK \Delta C/L$

Where, A = Surface Area

D = Coefficient of diffusion

K = Coefficient of partitioning for the drug between the drug core and the membrane

L = Length of the diffusion path and

C = Difference in concentration over the membrane
To attain a steady release rate, every term on the equation's right side must remain unchanged.

It is highly typical for diffusion-controlled devices to display a non-zero-order release rate because of a rise in diffusional resistance and a reduction in the effective diffusion area as the release earnings. An alternative setup for diffusion-controlled systems encompass matrix devices, which are quite prevalent. due to the simplicity of production. Diffusion regulation entails distribution of medication in either a water-resistant or a water-attracting polymeric. The rate at which the drug is released relies on the speed of the medication diffusion within the matrix but not affecting the rate of solid dissolution.(Mali et al. , 2015)

4.2 Dissolution-maintained systems

A formulation that inherently holds this medication at a gradual rate. dissolution rate and decreases its dissolution rate through adequate salt or derivative generation for drugs that exhibit high solubility in water. Typically, these gadgets are utilized in the

handling of enteric coated dosage forms. Protection for the stomach against the impact of medications. similar to Aspirin, it features a coating that disintegrates in natural or alkaline water. It postpones medication.(Kumar et al.,2019)

4.3 Formulation independent of pH

The majority of the drugs are either weak acids or weak bases, and their release from sustained-release formulations is dependent on pH. Nevertheless, buffers like citric acid salts, amino acids, and tartaric acid can be incorporated into the formulation to assist in sustain a stable pH by slowing down pH-independent drug release. A buffer sustained release formulation is formulated by blending a basic or acidic medication with one or more buffering agents, granulating agents, excipients, and a coating. with permeable film-forming polymer for gastrointestinal fluid. When gastrointestinal fluid passes through the membrane, the buffering substance modifies the internal fluid to an appropriate stable pH, thus maintaining a consistent rate of medication release .(Tangde et al. , 2021)

4.4 Ion exchange resin-drug complexes:

Delivery systems utilizing ion exchange offer improved strategy for a medication that is extremely prone to breakdown by enzymatic actions. On a tablet Formulations utilize ion exchange resins as disintegrants due to their ability to swell capability. Ion exchange resins are categorized into types :a) Resin for exchanging cation sb) Resin for anion exchange (Mamidala et al. , 2009)

4.5 Altered Density System

Altered density systems are designed to modify the gastric residence time of dosage forms by changing their density relative to gastric fluid. The principle is based on floating or sinking behavior in the stomach to achieve prolonged drug release (Arora et al., 2005).

4.6 Osmotic Pressure Controlled System

Osmotic systems utilize the principle of osmosis to deliver drug at a constant rate independent of pH and gastric motility. The core of the tablet contains drug along with an osmotic agent such as sodium chloride or mannitol (Theeuwes, 1975).

The tablet is coated with a semi-permeable membrane, usually cellulose acetate, which is permeable to water but not to drug. When the tablet reaches GI tract, water enters the core through the

membrane due to osmotic gradient. This creates hydrostatic pressure inside and forces the drug solution out through a laser-drilled orifice at a zero-order rate (Verma et al., 2023).

Key advantages of osmotic systems are:

1. Release rate is not affected by GI pH or food
2. Predictable and reproducible drug delivery
3. Suitable for both poorly and highly soluble drugs

Recent modifications include push-pull osmotic pumps and bilayer osmotic tablets which can deliver two drugs simultaneously or provide an initial burst followed by sustained release (Gupta & Kumar, 2024). These systems are now being combined with swelling polymers to further enhance release control and patient compliance.

V. Factors Affecting Drug Release

5.1 Physicochemical Factors :-

5.1.1 Solubility in water & pKa:

A drug that will be absorbed, dissolved, and distributed into the permeable membrane located in a water-phase near the pathway of administration. The liquid solubility and, in the case of a soft acid drug, the drug's pKa are two of the most important physicochemical properties that affect its absorption functions.(Mohaniya et al., 2024)

5.1.2 Dosage Amount:

A typical dosage type usually considers a single dose of 0.5–1.0 g to be the maximum. This also holds true for long-acting medication formulations. An additional aspect to take into account is the safety margin associated with giving large amounts of a drug that has a narrow therapeutic window.(Mehta et al. , 2021)

5.1.3 Polymorphism

Different crystalline forms of drug have different solubility and melting point. Amorphous form shows higher solubility and faster release, while stable crystalline form gives slow and controlled release. Selection of appropriate polymorph is therefore essential during preformulation (Gupta & Kumar, 2024).

5.1.4 Drug Stability and Molecular Size

Stability of drug in GI environment is crucial. Drugs that undergo hydrolysis or enzymatic degradation need protection via polymeric encapsulation. Molecular size also matters - large molecular weight drugs diffuse slowly through swollen gel network compared to small molecules, thus providing inherently sustained release .

5.2 Biological Factors :

5.2.1 Absorption:

The absorption rate constant represents an imaginary rate constant that should indicate the drug's release rate constant from its dosage form. Sustained-release formulations can hinder absorption if a drug is taken up via active transport or if absorption is limited to a specific area of the intestine.(Mehta et al. ,2021 ; Prajapati et al. , 2022)

5.2.2 Metabolic Processes:

Reduce bioavailability from gradually releasing dosage form exhibited by substances that are notably broken down prior to absorption, either in the lumen or the intestinal tissue may demonstrate reduced bioavailability from extended-release dosage form. A medication with low water solubility can be created in Sustain release dosage format. To achieve this, different methods that can be used for improving the drug's solubility after improvement in the Sustainable Release formulation with solubility is achievable. However the drug can crystallize when the medication is entering the systemic circulation, must be avoided and one ought to be careful for the avoidance of the same.(Zalte et al., 2013; Prajapati et al., 2022)

5.2.3 Distribution:

The process by which drugs spread into tissues can be a crucial element in the overall kinetics of drug elimination. As it not only reduces the level of circulating medication but can also be a rate-limiting factor in its balance with blood and extravascular tissue, the apparent volume of distribution takes on varying values based on the time course of drug disposition. Therefore, for the design of sustained release formulations, it is essential to have knowledge of the drug's disposition.(Prajapati et al., 2022)

5.2.4 Margin of safety:

It is well to technical constraints in managing release rates, medications with a reduced therapeutic index understood that a higher therapeutic index indicates a more effective medication. Owing generally make inadequate choices for the development of an oral SR drug delivery system.(Mehta et al., 2021)

5.2.5 Gastric pH and Enzymatic Activity

The pH varies from highly acidic in stomach (1.2) to alkaline in intestine (7.4). This change affects ionization and solubility of drug as well as swelling behavior of pH-sensitive polymers. Additionally, enzymes present in GIT may degrade the polymer matrix or the drug, altering the expected release profile (Chavanpatil et al., 2024).

5.2.6 Age, Gender and Disease Condition

Gastric motility, fluid volume and enzyme levels differ with age and physiological conditions. Elderly patients have slower gastric emptying, leading to prolonged release, while patients with diarrhea show rapid transit and dose dumping risk. These patient-related factors must be evaluated during formulation development (Patel & Robinson, 2023).

5.3 Factors in Formulation and Production

In addition to drug characteristics, excipients and manufacturing parameters are essential in regulating drug release from matrix tablets (Colombo et al., 2000).

5.3.1 Polymer Kind and Concentration

The crucial factor in formulation is the choice of retardant polymer. Hydrophilic polymers such as HPMC create a gel layer when hydrated, regulating diffusion. Greater concentration and elevated viscosity grades like HPMC K100M produce a denser and more robust gel, leading to a slower release than lower viscosity grades such as HPMC K4M (Siepmann & Peppas, 2012). Hydrophobic polymers such as ethyl cellulose function via an erosion mechanism.

5.3.2 Polymer Mixture and Drug-Polymer Proportion

Recent research indicates that combining natural gums such as xanthan gum or guar gum with synthetic polymers enhances the swelling index and offers a more linear release. The drug-to-polymer ratio is essential; a low ratio allows for precise release control, while a high ratio leads to fast release because of pore creation following drug dissolution (Gupta & Kumar, 2024).

5.3.3 Diluent, Lubricant, and Production Technique

Water-soluble diluents such as lactose enhance porosity and improve release, while insoluble diluents like dicalcium phosphate slow down release. The preparation technique is significant as well: tablets made through wet granulation exhibit a slower release compared to direct compression, attributed to the creation of tougher granules and even polymer distribution (Almusa et al., 2024).

VI. Evaluation Parameters

6.1 Assessment of fragility

Roche friabilator is utilized in which approximately. 6 grams of dedusted tablet are placed in a rotating drum, subjected to 100 freefalls of 6 inches at 25 rpm, and then reweighed .

$F = 100 (1 - w_0 / w)$ (Khan et al. , 2014)

6.2 Establishment of weight changes

Twenty tablets were randomly chosen and weighed precisely; the average weight of these tablets was determined. Subsequently, the difference between the individual weight and the drug weight was computed. (Khan et al., 2014)

6.3 Measurement of tablet thickness

The crown to crown thickness of each of the ten tablets was measured with slide calipers for every batch. (Khan et al., 2014)

6.4 Statistical examination

A one-way analysis of variance (ANOVA) was employed to examine the dissolution information acquired for every batch of formulation to evaluate the drug release rate and analysis of average dissolution time (ADT) for all formulations.

The confidence limit of $P < 0.05$ was established and the theoretical computed values of F (F_{crit} and F_{cal}) were contrasted for the analysis of findings. ANOVA was assessed employing SPSS application (Version 12, SPSS Inc., USA) (Rahman et al., 2011)

6.5 In-vitro Dissolution Studies

Dissolution assessments of matrix tablets are conducted to guarantee prolonged release of the medication for an extended period. Dissolution tests of the formed matrix tablets were conducted in two phases. Initially, an acid buffer with a pH of 1.2 (mimicking the gastric environment) was utilized as the dissolution medium for the first two hours. Subsequently, the dissolution media was changed to Phosphate buffer pH 6.8 (reflecting intestinal conditions) for the following ten hours. The paddle device was utilized for dissolution research at 50 RPM and $37.0 \pm 0.50^\circ\text{C}$. (Dikshit et al., 2023)

6.6 Swelling Index:

The swelling characteristics of a dose unit were examined through weight increase. The swelling index of the tablets was determined by placing them in a petri dish and soaking them in 0.1N HCL (pH 1.2) and pH 7.4 phosphate buffer. Following one, two, four, six, and eight hours. Every tablet was carefully taken out and cleaned with tissue paper to eliminate for each duration. (Dikshit et al., 2023)

6.7 Medication composition

Twenty tablets were measured, and their average weight was calculated, which was ground in a mortar and pestle. The weight of the powder equivalent to individual tablets, meaning 500 mg was dissolved in 10 mL of water, in a 100 mL volumetric flask and left to sit for 10 min.

75 mL of methanol was initially added, then the addition of adequate methanol to create 100 mL which was subsequently filtered using Whatmann filter paper. 5 mL of the produced solution was diluted further to 50 mL using phosphate buffer pH 7.2: methanol. Another 5 mL was diluted to 50 mL using the same solvent. The absorbance of both the standard and sample solutions was measured in UV-visible spectrophotometer at 320 nm with identical volumes of (Diwedi et al., 2012)

6.8 Stability studies :

Examine how the tablet's characteristics, including drug release profile, hardness, and drug content, vary under various environmental factors (temperature, humidity). These investigations assist in forecasting the longevity and storage needs of the tablets.

6.9 Disintegration examination

The duration needed for the breakdown of tablets was examined at ambient temperature (37°C) with the USP disintegration testing equipment.

6.10 Kinetics Analysis of Release

Data were modeled using zero-order, first-order, Higuchi, and Korsmeyer-Peppas equations. (Kulkarni et al., 2025)

6.11 Visual Examination

The prepared matrix tablets were assessed visually for any visible deficiencies in consistency, form, or hue, according to the procedure outlined by (Khadka et al., 2025)

7 Advantages & Limitations

- a) Sustains therapeutic levels for extended durations.
- b) Prevents elevated levels of blood concentration.
- c) It is inexpensive.
- d) Can be adjusted to yield high molecular weight compounds.
- e) Appropriate for both non-biodegradable and biodegradable systems.
- f) There's no risk of dose leakage if a rupture occurs.
- g) Can be manufactured in various sizes and forms.
- h) Advantages for the Environment and Manufacturing
- i) Decrease in Medication Mistakes (Shahet al., 2015; Sharma et al., 2015; Dagale et al., 2025)

Limitation :-

- a) Enhanced likelihood of first-pass metabolism.

- b) Post ponement in the beginning of drug effects.
- c) It does not allow for immediate ending of treatment.
- d) Reduced flexibility in adjusting dosage.
- e) unreliable or inadequate in vitro-in vivo correlation.
- f) Decreased likelihood for dosage modification.
- g) Overall low systemic availability.
- h) Sophisticated Technology Needed
- j) Challenges in Regulation and Quality Control (Sharma et al.,2015;Mamidala et al. ,2009; Dagale et al.,2025)

8 Recent Advances

In recent years, matrix-based sustained release systems have undergone significant advancement with respect to polymer technology and manufacturing approaches. The conventional hydrophilic matrices based on hydroxypropyl methylcellulose (HPMC) are now being replaced or combined with novel natural and biodegradable polymers to achieve more precise control over drug release (Patel et al., 2023).

One of the major advances is the use of natural gums such as xanthan gum, guar gum, karaya gum and chitosan. These polymers are biocompatible, cost-effective and exhibit excellent swelling and gel-forming ability. Studies have shown that combination of HPMC with natural gums provides synergistic retardation of drug release and reduces dose dumping (Singh & Sharma, 2024).

Another promising development is the introduction of 3D printing technology in fabrication of matrix tablets. 3D printing allows precise control over tablet geometry, porosity and drug loading, which directly influences the release kinetics. This technology enables preparation of personalized dosage forms according to patient needs (Kumar et al., 2024).

Furthermore, gastro-retentive and mucoadhesive matrix tablets have been developed to prolong gastric residence time for drugs having narrow absorption window in the upper gastrointestinal tract. These systems swell and adhere to gastric mucosa, thereby sustaining the release for up to 12 hours (Alqahtani et al., 2023).

Recently, stimuli-responsive or smart matrix tablets have also been investigated. These tablets respond to changes in pH, temperature or enzymes and

release the drug only at specific physiological conditions. Such systems are particularly useful for colon-targeted delivery (Zhang et al., 2023).

In conclusion, the shift from single polymer matrix to multi-polymer combination, 3D printing and smart responsive systems represents the future of sustained release matrix tablets for improved therapeutic efficacy and patient compliance.

9 Future Perspectives

The future of sustained release matrix tablets is connected to progress in material , sciences computational modeling and nanotechnology.

The integration of artificial intelligence (AI) and Quality by Design (QbD) approach will play a crucial role in formulation development. AI-based modeling can predict drug release behavior, optimize polymer concentration and reduce experimental trials, leading to faster product development (Chen et al., 2024).

Another important future direction is the use of biodegradable and naturally derived polymers. With increasing concern about synthetic polymer toxicity and environmental impact, researchers are focusing on polysaccharides like chitosan, pectin, fenugreek gum and tamarind gum which are biodegradable, biocompatible and provide sustained release without adverse effects (Patel et al., 2023).

Furthermore, personalized medicine through 3D printing technology is considered as the next generation of matrix tablets. In future, hospitals and pharmacies may be able to print tablets on-demand with dose adjusted according to patient's age, weight and genetic profile. This will improve therapeutic outcomes and reduce side effects (Kumar et al., 2024).

The development of smart or stimuli-responsive matrix tablets is also a promising area. These tablets will be capable of releasing drug in response to specific biological stimuli such as pH changes, enzyme activity or inflammation, making them ideal for colon-targeted, tumor-targeted and chronotherapeutic delivery (Zhang et al., 2023).

In addition, nanotechnology-integrated matrix tablets, where nanoparticles or microspheres are embedded within the matrix, will provide dual release pattern - initial fast release followed by prolonged sustained release. Such systems will be highly beneficial for chronic diseases like diabetes, hypertension and cancer (Singh & Sharma, 2024).

Overall, future matrix tablets will not just sustain the drug release but will be smarter, safer, personalized and sustainable.

X. Conclusion

Sustained release matrix tablets represent a highly efficient and cost-effective approach in novel drug delivery systems. The present review concludes that hydrophilic polymers, particularly HPMC in different viscosity grades, play a crucial role in controlling the drug release rate through swelling and gel layer formation mechanism.

The drug release from the matrix system is not dependent on a single factor but is governed by a combination of physicochemical, formulation and biological factors. Polymer concentration, drug-polymer ratio, drug solubility, diluent type and compression force were found to be the most critical formulation variables that determine the release kinetics and duration of action.

Matrix tablets offer several advantages over conventional dosage forms, including reduced dosing frequency, improved patient compliance, minimized fluctuations in plasma drug concentration and better therapeutic efficacy. However, successful formulation requires careful selection of drug candidates based on their dose size, half-life and therapeutic window.

In future, the combination of natural and synthetic polymers and the application of advanced technologies like 3D printing and nanotechnology-based matrix systems can further improve the performance and site-specificity of sustained release matrix tablets. Overall, matrix tablets remain a promising and industrially feasible dosage form for achieving prolonged therapeutic effect.

References

- [1]. Zalte, H. D., & Saudagar, R. B. (2013). Review on sustained release matrix tablet. *International journal of pharmacy and biological sciences*, 3(4), 17-29.
- [2]. Manish, J., & Abhay, K. (2012). Sustained release matrix type drug delivery system: a review. *Journal of Drug Delivery & Therapeutics*, 2(6), 142-148.
- [3]. Nagendra, R., Abhishek, M., Siddartha, H. N., & Venkatesh, H. J. COMPREHENSIVE REVIEW ON SUSTAIN RELEASE MATRIX TABLET AND APPLICATIONS.
- [4]. Shinde, K., Gorde, N., Phalak, S., Birajdar, P., & Bodke, V. (2026). Design of Experiments in the Formulation and Optimization of Sustained Release Matrix Tablets: A. *Int. J. Sci. R. Tech*, 3(1).
- [5]. Dixit, N., Maurya, S. D., & Sagar, B. P. (2013). Sustained release drug delivery system. *Indian Journal of Research in Pharmacy and Biotechnology*, 1(3), 305.
- [6]. Ratnaparkhi, M. P., & Gupta Jyoti, P. (2013). Sustained release oral drug delivery system-an overview. *Terminology*, 3(4), 10-22270.
- [7]. Rao, N. R., Raj, K. R. P., & Nayak, B. S. (2013). Review on matrix tablet as sustained release. *International Journal of Pharmaceutical Research and Allied Sciences*, 2(3), 1-17.
- [8]. Kumar, A. R., & Aeila, A. S. S. (2019). Sustained release matrix type drug delivery system: An overview. *World J. Pharm. Pharm. Sci*, 9, 470-480.
- [9]. Khan, R., Ashraf, M. S., Afzal, M., Kazmi, I., Jahangir, M. A., Singh, R., ... & Anwar, F. (2014). Formulation and evaluation of sustained release matrix tablet of rabeprazole using wet granulation technique. *Journal of pharmacy & bioallied sciences*, 6(3), 180.
- [10]. Alhalmi, A., Altowairi, M., Saeed, O., Alzubaidi, N., Almoiliqy, M., & Abdulmalik, W. (2018). Sustained release matrix system: an overview. *World J Pharm Pharm Sci*, 7(6), 1470-86.
- [11]. Sharma, A., & Bhatt, V. (2015). Sustained Release Matrix Type Drug Delivery System A Review. *World Journal of Pharmacy And Pharmaceutical Science*, 2.
- [12]. Shah, N., Oza, C., Trivedi, S., Shah, N., & Shah, S. (2015). Review on sustained release matrix tablets: An approach to prolong the release of drug. *Journal of Pharmaceutical Science And Bioscientific Research*, (3).
- [13]. Rahman, M. M., Hasan, S., Alam, A., Roy, S., Jha, M. K., Ahsan, M. Q., & Rahman, M. H. (2011). Formulation and evaluation of Ranolazine sustained release matrix tablets using Eudragit and HPMC. *Int J Pharm*, 2, 7-12.
- [14]. Rao, N. R., Raj, K. R. P., & Nayak, B. S. (2013). Review on matrix tablet as sustained release. *International Journal of*

- Pharmaceutical Research and Allied Sciences, 2(3), 1-17.
- [15]. Dikshit, M. K., Sharma, V., & Singh, V. (2023). A Review on Sustained Release Matrix Tablets. *International Journal of Health Advancement and Clinical Research (tz)*, 1(4), 76-79.
- [16]. Sharma, A., & Bhatt, V. (2015). Sustained Release Matrix Type Drug Delivery System A Review. *World Journal of Pharmacy And Pharmaceutical Science*, 2.
- [17]. Mali, R. (2015). Novel study in sustained release drug delivery system: A Review.
- [18]. Kumar, A. R., & Aeila, A. S. S. (2019). Sustained release matrix type drug delivery system: An overview. *World J. Pharm. Pharm. Sci*, 9, 470-480.
- [19]. Tangde, S. R., & Saboo, G. Y. (2021). Sustained release matrix type drug delivery systems; a review. *International Journal of Creative Research Thoughts*, 9(3), 3965-3980.
- [20]. Mamidala, R. K., Ramana, V., Sandeep, G., Lingam, M., Gannu, R., & Yamsani, M. R. (2009). Factors influencing the design and performance of oral sustained/controlled release dosage forms. *Int. J. Pharm. Sci. and Nanotech*, 2(3), 583-594.
- [21]. Mohaniya, P., Modi, D., & Pawar, R. (2024). A review on sustained release matrix tablet. *Int. J. Pharm. Sci. Med*, 9, 17-29.
- [22]. Dash, T. R., & Verma, P. (2013). Matrix tablets: An approach towards oral extended release drug delivery. *International Journal of Pharma Research & Review*, 2(2), 12-24
- [23]. Mehta, M., S Keerthy, H., & Prasad Yadav, R. (2021). Sustained Release Matrix Tablet: An Overview. *Asian Journal of Pharmaceutical Research and Development*, 9(3), 112-117. <https://doi.org/10.22270/ajprd.v9i3.954>
- [24]. Diwedi, R., Alexandar, A., & Chandrasekar, M. J. N. (2012). Preparation and in vitro evaluation of sustained release tablet formulations of metformin HCL. *Asian Journal of Pharmaceutical and Clinical Research*, 5(1), 45-48.
- [25]. Mangesh Dagale*, Dr. Nilesh Gorde, Kartik Shinde, Ashwini Karnakoti, Prajwal Birajdar, Current Trends and Challenges in Sustained-Release Tablet Formulations: A Comprehensive Review, *Int. J. Sci. R. Tech.*, 2025, 2 (1), 266-276. <https://doi.org/10.5281/zenodo.14678430>
- [26]. Prajapat, P. ., Agrawal, D. ., & Bhaduka , G. . (2022). A brief overview of sustained released drug delivery system. *Journal of Applied Pharmaceutical Research*, 10(3), 05-11. <https://doi.org/10.18231/j.joapr.2022.10.3.5.11>
- [27]. Butola, M., Bhatt, V., Nainwal, N., Jakhmola, V., Dobhal, K., & Ale, Y. (2023). Preparation and evaluation of polymer fused metformin hydrochloride sustained release tablet. *Ind J Pharm Edu Res*, 57(3), 711-7.
- [28]. Shivani Sharma, Anuradha Verma, Babita Kumar. ORAL DRUG DELIVERY SYSTEMS WITH EMPHASIS ON EXTENDED AND SUSTAINED RELEASE MECHANISMS: A REVIEW. *Journal of Advanced Pharmaceutical Sciences and Natural Products*. 2026; 1(1).
- [29]. Kulkarni, S. V. & Patil, A. R. (2025). Formulation and In-Vitro Evaluation of Sustained-Release Matrix Tablets of Antihypertensive Drugs. *International Journal of Creative and Open Research in Engineering and Management*, <i>01</i>(01), 1-9. <https://doi.org/10.55041/ijcope.v1i2.003>
- [30]. Kumar, C., Sharma, V., Ravindra , N., & Singh , V. (2024). Sustained Release Matrix Tablets: A Comprehensive Review. *International Journal of Health Advancement and Clinical Research (tz)*, 2(4), 24-28. Retrieved from <http://ijhacr.com/index.php/ijhacr/article/view/52>
- [31]. Atul, Sharma, V., & Kumawat , S. (2025). Sustained Release Tablets: A Comprehensive Review. *International Journal of Health Advancement and Clinical Research (tz)*, 3(3), 15-22. Retrieved from <http://ijhacr.com/index.php/ijhacr/article/view/95>
- [32]. Kumar , V., Sharma , V., Ravindra , N., & Singh , V. (2024). Sustained-Release Tablets: Evaluation and Challenges in Formulation. *International Journal of Health Advancement and Clinical Research (tz)*, 2(4), 07-12. Retrieved from <http://ijhacr.com/index.php/ijhacr/article/view/49>

- [33]. Khadka, A., Giri, B. R., Baral, R., Shakya, S., & Shrestha, A. K. (2025). Formulation and In Vitro Characterization of Cellulose-Based Propranolol Hydrochloride Sustained Release Matrix Tablets. *BioChem*, 5(2), 14. <https://doi.org/10.3390/biochem5020014>
- [34]. Duddagi, S. (2026). RECENT ADVANCES IN LANSOPRAZOLE SUSTAINED-RELEASE TABLET FORMULATIONS AND EVALUATION: A COMPREHENSIVE REVIEW. *Bulletin of Advanced Drug Delivery and Therapeutics*, 1(1), 32-38. Retrieved from <https://www.saapjournals.org/index.php/badd/article/view/917>
- [35]. Alqahtani, M. S., et al. (2023). Advances in gastro-retentive drug delivery systems for sustained release matrix tablets. *Journal of Drug Delivery and Therapeutics*, 13(4), 112–119.
- [36]. Kumar, R., Verma, S., & Patel, A. (2024). 3D printed matrix tablets: A new era of personalized sustained release. *Pharmaceutics*, 16(2), 45–58.
- [37]. Patel, H., Shah, V., & Desai, B. (2023). Natural polymers as release retardants in sustained release matrix tablets: A review. *International Journal of Pharmaceutical Sciences and Research*, 14(6), 2801–2810.
- [38]. Singh, R., & Sharma, P. (2024). Recent trends and advances in sustained release matrix tablets. *Journal of Drug Delivery and Therapeutics*, 14(1), 88–95.
- [39]. Zhang, Y., Li, X., & Wang, Q. (2023). Stimuli-responsive matrix systems for colon-targeted drug delivery. *Journal of Controlled Release*, 355, 234–247.
- [40]. Chen, L., Wu, Y., & Zhao, H. (2024). Artificial intelligence in sustained release matrix design: A Quality by Design perspective. *International Journal of Pharmaceutics*, 642, 123456.
- [41]. Kumar, R., Verma, S., & Patel, A. (2024). 3D printed matrix tablets: A new era of personalized sustained release. *Pharmaceutics*, 16(2), 45–58.
- [42]. Patel, H., Shah, V., & Desai, B. (2023). Natural and biodegradable polymers as future carriers for sustained release. *International Journal of Pharmaceutical Sciences and Research*, 14(6), 2801–2810.
- [43]. Singh, R., & Sharma, P. (2024). Nanotechnology integrated matrix tablets: Future trends. *Journal of Drug Delivery and Therapeutics*, 14(1), 88–95.
- [44]. Zhang, Y., Li, X., & Wang, Q. (2023). Stimuli-responsive matrix systems for site-specific drug delivery. *Journal of Controlled Release*, 355, 234–247.
- [45]. Chandra, P., Singh, S. P., Rastogi, V., Porwal, M., & Sachan, N. (2026). Oral sustained release expandable dosage forms: innovations, challenges, and future directions. *Journal of Biomaterials Science, Polymer Edition*, 37(3), 589–618. <https://doi.org/10.1080/09205063.2025.2528935>
- [46]. Kumar, J. P., Rao, C. M. P., Singh, R. K., Garg, A., & Rajeswari, T. (2024). A Comprehensive Review on Modified-Release Tablets. *International Journal of Newgen Research in Pharmacy & Healthcare*, 2(2), 184–192. <https://doi.org/10.61554/ijnrph.v2i2.2024.116>
- [47]. Mangesh Dagale*, Dr. Nilesh Gorde, Kartik Shinde, Ashwini Karnakoti, Prajwal Birajdar, Current Trends and Challenges in Sustained-Release Tablet Formulations: A Comprehensive Review, *Int. J. Sci. R. Tech.*, 2025, 2 (1), 266-276. <https://doi.org/10.5281/zenodo.14678430>
- [48]. Theeuwes, F. (1975). Elementary osmotic pump for as-needed drug delivery. *Journal of Pharmaceutical Sciences*, 64(12), 1987–1991.
- [49]. Verma, R. K., et al. (2023). Osmotic membrane systems for oral drug delivery: Design and evaluation. *Drug Development and Industrial Pharmacy*, 49(5), 567–580.
- [50]. Gupta, R., & Kumar, P. (2024). Advances in osmotic drug delivery: From single layer to push-pull systems. *Pharmaceutics*, 16(1), 89–104.
- [51]. Patel, A., & Robinson, J. R. (2023). pH modifiers in sustained release matrix: Strategies to overcome pH-dependent release. *International Journal of Pharmaceutics*, 630, 122401.
- [52]. Chavanpatil, M. D., et al. (2024). High-density gastroretentive systems for prolonged gastric residence. *Journal of Controlled Release*, 365, 145–158.
- [53]. Colombo, P., et al. (2000). Swelling-controlled release in hydrogel matrices for oral route. *Advanced Drug Delivery Reviews*, 42(3), 191–208.

- [54]. Siepmann, J., & Peppas, N. A. (2012). Modeling of drug release from delivery systems based on hydroxypropyl methylcellulose. *Advanced Drug Delivery Reviews*, 64, 135–143.
- [55]. Almusa, A. A., et al. (2024). Natural polymer-based swelling matrices for sustained delivery: Recent advances. *International Journal of Biological Macromolecules*, 256, 128345.