Strontium Infused Bioactive Materials Bactericidal Effect on Streptococcus Mutans

Anushka Ashok1 , S.Rajesh1,a)

1Anu Health enterprises, Bhubaneshwar, Orissa, India

**Corresponding Author**: a)[sharonrajeshsdc@gmail.com](mailto:sharonrajeshsdc@gmail.com)

**ABSTRACT:** *Streptococcus mutans* belong to the category of gram-positive bacteria that reside within the human oral cavity. Postal Adhesion enables this bacteria to bind to tooth surfaces where it creates dental plaque as biofilms. Bioactive materials show great potential in dental applications because they form a positive relationship with biological tissues while stimulating healing. These materials are designed to provide structural support and deliver therapeutic effects. Synthesis of bioglass followed by disinfection of dentin bio slabs with 1% sodium hypochlorite Washing of dentin slabs in 17% EDTA and DD Water Sr-BG treatment has a significant inhibitory effect on bacterial growth compared to the control. Sr-BG has a cytotoxic effect, leading to a reduction in cell viability compared to the control. And can target pathogenic viruses Strontium's bactericidal effects disrupts bacterial cell wall integrity and interfere with vital enzymatic processes within S.mutans, leading to cell death. Additionally, strontium ions may inhibit biofilm formation, which is critical as it provides a protective environment for bacteria, making them more resistant to conventional treatments.The development of strontium-infused bioactive materials represents a significant advancement in dental care, offering a novel approach to combat dental caries through targeted antibacterial action and dental tissue remineralization.

**KEYWORDS:** Bioglass; Antibacterial; *Streptococcus mutans;* Remineralization .

# INTRODUCTION

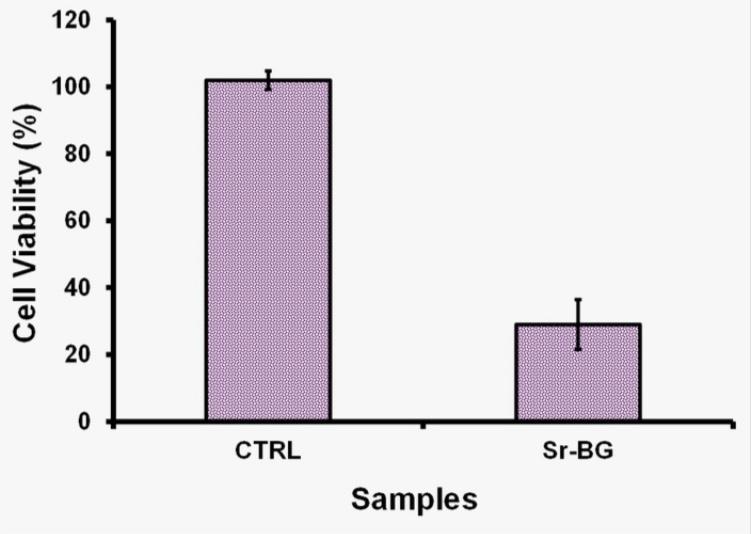
*Streptococcus mutans* function as a key microorganism responsible for calcium loss that leads to dental caries development in human oral cavities. The bacteria dwell primarily in biofilms that develop on tooth surfaces and dental professionals term this entity as dental plaque ([(Lemos et al., 2019)](https://paperpile.com/c/gD1SYC/xs1j). Staphylococcus mutans as bacteria exist within the human oral cavity and classify under the gram-positive category. The microorganism binds tooth surfaces to develop biofilms which demonstrate resistance to typical antimicrobial treatments. Tooth enamel becomes demineralized through the dental cavity process due to acid fermentation from S. mutans. The successful control of dental caries requires proper management of S. mutans [(Simón-Soro & Mira, 2015)](https://paperpile.com/c/gD1SYC/HOog)[(Dharman 2021)](https://paperpile.com/c/gD1SYC/opknX).The standard approach to dental caries treatment includes cleaning biofilms from teeth followed by fluoride administration and antimicrobial prescription medication use. The established antimicrobial and biofilm removal approaches suffer from multiple problems such as microbial resistance formation and limited penetration into biofilm structures together with possible harmful side effects. The search for different methods has intensified due to modern treatment limitations. [(“Antibacterial Effect of a New Bioactive Glass on Cariogenic Bacteria,” 2020)](https://paperpile.com/c/gD1SYC/qO4C) [(Neha et al., 2021)](https://paperpile.com/c/gD1SYC/ThO9j)[(Maliael et al., 2021)](https://paperpile.com/c/gD1SYC/ulivZ)[(Lakshmi, 2021)](https://paperpile.com/c/gD1SYC/vsmke).Bioactive materials present significant potential for dental usage because they establish positive contact with biological tissues while supporting healing processes. The materials serve a dual purpose since they fulfill load-bearing needs and simultaneously produce therapeutic results. Bioactive materials become more effective against infections while simultaneously stimulating dental tissue regeneration when antimicrobial agents are integrated into their structure. [(Tanaka et al., 2023)](https://paperpile.com/c/gD1SYC/xJFy) [(Sabarathinam & Madhulaxmi, 2021)](https://paperpile.com/c/gD1SYC/FOToo)[(Sushanthi et al., 2021)](https://paperpile.com/c/gD1SYC/fu7Gb)[(Harsha et al., 2022)](https://paperpile.com/c/gD1SYC/UzYHH)Both strontium (Sr) functions as a trace element which benefits bone health while strengthening bioactive materials through its property-enhancing capability. Scientists add strontium ions into bioactive materials to enhance their performance as well as mechanical capabilities. Strontium demonstrates three key functions of stimulating new bone generation and blocking bone loss processes while preventing microorganism growth. Strontium demonstrates properties which enable its use as an attractive component for producing bioactive materials that fight S. mutans. [(Alshammari et al., 2021)](https://paperpile.com/c/gD1SYC/ZgyE) [(Tiwari & Jain, 2023)](https://paperpile.com/c/gD1SYC/ntwTA)[(Graf et al., 2023)](https://paperpile.com/c/gD1SYC/d6p2w)The research evaluates how strontium-infusion in bioactive materials impacts their performance against Streptococcus mutans. We integrate strontium into bioactive materials to enhance the antimicrobial properties which will enable better S. mutans dental caries management according to our hypothesis [(Albannawi, n.d.)](https://paperpile.com/c/gD1SYC/c3pS) [(Jabin et al., 2021)](https://paperpile.com/c/gD1SYC/qtUNZ)[(Balaji Ganesh S & Sugumar, 2021)](https://paperpile.com/c/gD1SYC/ey69L) [(Govindaraj & Dinesh, 2021)](https://paperpile.com/c/gD1SYC/r44k3) . These findings might lead to new dental materials merging therapeutic and preventive features against oral bacterial infections.

## MATERIALS AND METHODS

A solution made from silica constitutes the starting point in bioglass production. The key component silica gets blended with water to produce an appearance similar to gel. The proper structure of bioglass relies heavily on silica therefore this step remains fundamental. The addition of phosphate depends on achieving a uniform silica solution because this procedure leads to enhanced bioactivity in the glass. The procedure requires the addition of salt followed by calcium. The bioglass-biological tissue interaction becomes more effective thanks to these ions which support the hydroxyapatite (biological tooth and bone mineral) production process [(S et al., 2022)](https://paperpile.com/c/gD1SYC/YJJM).The mixture receives strontium after sodium and calcium have been added(Rafi et al., 2024). The property of strontium to stimulate bone regrowth while restraining bone tissue breakdown turned it into an essential composition ingredient for bioglass especially when used in dental practices and orthopedic surgeries. Additional bioactivity occurs through the synthesis process inclusion of strontium nanotubes. The increased surface area of these nanotubes enhances material reactivity which helps therapeutic ions release from the bioglass during biological application.The treatment of dentin slabs begins with soaking them in 1% sodium hypochlorite solution. Primitive pollutants together with bacterial agents need removal from dentin surfaces before any treatment starts (Tuluwengjiang et al., 2024). The slabs undergo 17% EDTA (Ethylenediaminetetraacetic acid) treatment to remove the smear layer that results from cutting or dentin preparation procedures following complete disinfecting solution with 17% EDTA. Better interaction between Bioglass and dentin occurs due to this cleaning protocol. Thorough sanitation of the prepared slabs takes place following double-distilled (DD) water rinsing.The dentin slabs need synthetic saliva immersion for simulating oral conditions after their preparation process. The integration of strontium-infused bioglass with dentin occurs more readily when artificial saliva is provided as an additional application. Bioactive ions dissolve from the bioglass because artificial saliva controls both pH levels and ion composition. Strontium-based treatments contribute heavily to enhancing both the compatibility and functional capabilities of bioglass when used in dentistry since the strontium and densified structure accelerate tooth remineralization and lead to dentin reinforcement [(Shivalingam et al., 2024)](https://paperpile.com/c/gD1SYC/6uST).

# RESULTS

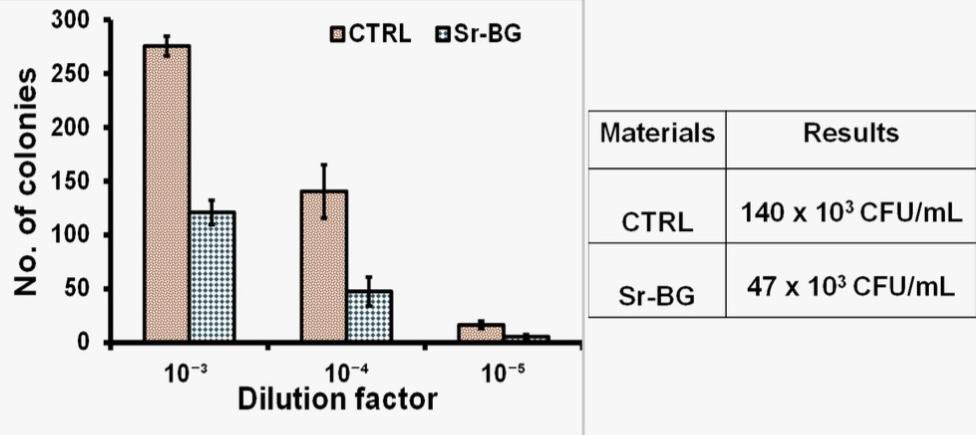
## Cell viability of Streptococcus mutans



**Figure 1:** Cell viability of *Streptococcus mutans* using MTT assay.

Figure 1 shows the results of the MTT assay, which measures cell viability. The two samples compared are CTRL (Control) and Sr-BG (Strontium-infused Bioactive Glass) treated cells. Pure cell viability taken as 100%, indicating that the control group cells are healthy and unaffected. Sr-BG exposure leads to a low cell viability level of approximately 30% based on the experimental data indicating strong inhibition of cellular survival. The cytotoxic properties of Sr-BG enable this substance to decrease cell viability to lower levels than control groups thus demonstrating potential as a pathogenic killer.

## Minimal inhibitory concentration *Streptococcus mutans*



**Figure 2:** colony forming unit based on minimal inhibitory concentration.

Figure 2 compares the results of the two treatments: CTRL (Control) and Sr-BG(Strontium-infused Bioactive Glass) in terms of (CFU/mL).In CTRL group the result shows 140 × 10³ CFU/mL, indicating a higher number of colonies and thus, more bacterial growth. In Sr-BG (Strontium-infused Bioactive Glass) the result shows 47 × 10³ CFU/mL,indicating a lower number of colonies, thus, less bacterial growth compared to the control. This shows that the Sr-BG treatment has a significant inhibitory effect on bacterial growth compared to the control.Strontium's bactericidal effects disrupt bacterial cell wall integrity and interfere with vital enzymatic processes within S.mutans, leading to cell death. Additionally, strontium ions may inhibit biofilm formation, which is critical as it provides a protective environment for bacteria, making them more resistant to conventional treatments. Such materials help dental tissues to regain their lost minerals. When used with dentistry materials the substance helps control bacteria while assisting enamel repair and improving its physical state. These dental materials protect teeth from caries damage in dental fillings and sealants and varnishes through their extended release of strontium ions. The extended strontium ion release of these materials provides an extended antibacterial effect which improves patient adherence to care by minimizing the frequency of product replacement [(Chitra et al., 2020)](https://paperpile.com/c/gD1SYC/5VDp).

# DISCUSSION

Another important part of strontium's antibacterial effect is how it interacts with bacterial biofilms. Strong biofilms that S. mutans creates on dental surfaces are well known for shielding the bacteria from harm and boosting their resistance to traditional antimicrobial treatments. By changing the ionic equilibrium inside the biofilm matrix, materials infused with strontium can prevent the production of biofilms. [(Khvostenko, 2014)](https://paperpile.com/c/gD1SYC/Qcjl)[(Ajay, Suma, et al., 2022)](https://paperpile.com/c/gD1SYC/lmwlz) [(Katyal et al., 2021)](https://paperpile.com/c/gD1SYC/RDbyK). The biofilm's structure is weakened by this disruption, increasing its susceptibility to antimicrobial agents. Furthermore, the combination of strontium with the release of calcium and phosphate ions encourages remineralization and further prevents the formation of biofilm, making it more difficult for S. mutans to colonize the tooth surface.[(Ajay, Rakshagan, et al., 2022)](https://paperpile.com/c/gD1SYC/aWVQ)Strontium-infused bioactive materials have antibacterial qualities as well as aid in the remineralization of demineralized enamel, which is a vital step in the prevention and treatment of early-stage caries. Similar to calcium, strontium is involved in the synthesis of hydroxyapatite, the mineral that makes up enamel. [(“Sol-Gel Bioactive Glass Containing Biomaterials for Restorative Dentistry: A Review,” 2022)](https://paperpile.com/c/gD1SYC/9lQ9)The resultant substance in hydroxyapatite is frequently more resistant to acid dissolution when strontium ions take the place of calcium ions. This resistance strengthens enamel's protective properties and slows the spread of dental cavities. Furthermore, strontium is useful in dental implants and other restorative operations where encouraging tissue integration is crucial because of its capacity to induce bone regeneration.[(de Oliveira Roma et al., 2023)](https://paperpile.com/c/gD1SYC/pi3p) [(Harsha & Subramanian, 2022)](https://paperpile.com/c/gD1SYC/2RXXA)[(Deepika et al., 2022)](https://paperpile.com/c/gD1SYC/aetwZ)[(Solanki et al., 2022)](https://paperpile.com/c/gD1SYC/xu2CF)Long-term performance issues exist regarding strontium-infused bioactive materials since they show promising properties for antibacterial functions and enamel remineralization. One major problem exists in the continuing long-term distribution of strontium ions. Strontium ion delivery rates require precise control regardless of the advantages of long-lasting antibacterial protection [(de Oliveira Roma et al., 2023)](https://paperpile.com/c/gD1SYC/pi3p). Fast releases deplete strontium ions prior to permanent effects while slow releases cannot achieve strong initial antibacterial response. The best antibacterial outcome alongside remineralization requires matching the strontium ion release rate of this material [(Kametani et al., 2024)](https://paperpile.com/c/gD1SYC/95Nt).Appropriate consideration should be given to the mechanical stability properties of strontium-introduced dental materials. Strong mechanical stresses during chewing and grinding are experienced by dental restoratives such as sealants along with crowns and fillings. Materials which incorporate strontium ions might alter their mechanical properties. Some studies show that strontium strengthens bioactive materials yet excess strontium can lead to weakened mechanical properties of dental materials. Additional research is required to establish the correct amount of strontium ions which will strike a balance between material strength and biological activity. [(Diniz et al., 2023)](https://paperpile.com/c/gD1SYC/QpNY)The bactericidal effect of strontium-infused bioactive materials makes them highly effective agents in dental caries prevention and treatment according to earlier research [(Diniz et al., 2023)](https://paperpile.com/c/gD1SYC/QpNY). Enhanced durability of these materials depends on better control of their release kinetics along with their mechanical behavior during extended use. Research objectives must focus on maximizing these parameters to enable strontium-based materials for their full utilization in present-day dental practices. [(Mayumi et al., 2021)](https://paperpile.com/c/gD1SYC/nrvB)

# CONCLUSION

​​Strontium-infused bioactive materials emerged as an essential dental breakthrough that provides two critical benefits consisting of antibacterial treatment and tissue remineralization. These materials demonstrate the potential to improve oral health outcomes because research should address current obstacles through expansion. This material promotes remineralization of dental tissues and also helps in controlling bacterial populations and aids in repairing and strengthening tooth enamel. Incorporating these materials into dental products such as fillings, sealants, and varnishes provides long-lasting protection against caries. The ability of these materials to release strontium ions over extended periods ensures sustained antibacterial activity, potentially reducing the need for frequent reapplication and enhancing patient compliance.

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